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Electrochemical Industry

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ADVERTISING RATES GIVEN ON APPLICATION.

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CONTENTS.

Editorial	557
The Outcome of the Aluminium Litigation.....	560
International Electric Congress.....	560
Contact Resistances and Current Leakages in an Electrolytic Copper Refinery. By B. Magnus.....	561
Insulating Paints. By M. Toch.....	562
International Congress for Applied Chemistry. By H. Danneel and J. K. Clement.....	563
Electrochemistry at the Massachusetts Institute of Technology.....	568
Historical Sketch of the Development in the Production of Copper, Nickel and Zinc from Chloride Solutions. By W. Koehler.....	568
The Sodium Industry in France. By P. Lethuile.....	573
The Role of Formation Heats of Alloys in Electrolysis. By J. W. Richards	575
Kjellin's Electric Furnace at Gysinge, Sweden, for the Manufac- ture of Steel. By F. C. Perkins.....	576
Dr. Hans Goldschmidt's Lecture on Aluminothermics.....	578
Schuckert System for the Electrolysis of Water.....	579
The Electrical Conductivity of Commercial Copper. By Lawrence Addicks	580
Synopsis of Articles in Other Journals.....	583
Analysis of Current Electrochemical Patents. By Geo. P. Scholl....	587
Book Reviews.....	593
Correspondence: Ether Extraction by Electrical Heat. By H. M. Burr	594
Dryers	594
Measurement of High Temperatures.....	595
Stoneware Exhaust Fan.....	596
Personal	597
Industrial Notes.....	597
Digest of United States Patents, Prior to July, 1902. By Byrnes & Townsend. (Chemicals).....	598

THE INDEX TO OUR FIRST VOLUME.

Once in each year the editor of a technical journal is permitted to publish an advertisement for his journal—the index accompanying the last issue of the volume. If the editor is inclined to statistics or statistical tricks, he may supplement the dry columns of names and titles by a bewildering array of figures, to prove to even the most incredulous reader that his journal is the only perfect one of its kind. Since the writer's talent for statistical fireworks is small, he may be permitted to say a few words concerning some questions which came up in the preparation of the index. If, besides fulfilling the useful purpose of an editorial advertisement, an index be good for anything, everybody of ordinary intelligence must be enabled to find with its aid the information which he looks for, if it is contained in the volume. Too much valuable information is buried forever in excellent periodicals simply on account of defective indexes. We are far from believing that our index is perfection, but we may say that we have tried at least to prepare it with the greatest possible care. We have endeavored to classify the subjects as much as possible. For instance, all mercury cathode processes for electrolyzing sodium chloride are collected together, whatever the title of the article may be in which the information appears. This principle is followed where it was possible. In the case of storage batteries, where such a classification would have been highly desirable it was found to be impossible, and was given up as a bad job. Whenever an article on a certain subject contains incidentally valuable information on another subject, the index should show it. Whenever new terms are proposed by an author, they are given in the index, so that if they should be used later without explanation, the reader may find their definition. Cross references have been given wherever it seemed advisable. While it would be the best thing to have always in mind all the information on a certain subject, the next best thing is to know how and where to find this information, and we hope that our index will be helpful to our readers in this direction.

ELECTROLYTIC COPPER REFINING.

Electric copper refining is that branch of electrometallurgy which without doubt has achieved the greatest commercial importance. The yearly output of the electrolytic refineries of this country alone is now estimated at 280,000 tons of copper. The importance which this industry has attained is mainly due to the excellence of the product. To measure the degree of purity of copper, we still use Matthiessen's old standard of electrical conductivity, although the figures for the purity of the commercial copper of to-day, based on this standard, have a very significant appearance, being often above 100 per cent. To quote a remark of Mr. Addicks in a paper

printed in this issue, the fact that the quality of the copper on the market to-day often exceeds by as much as 1 per cent the purest laboratory copper of forty years ago, forms an interesting commentary on the excellence of modern industrial methods.

One point which characterizes the modern American methods of copper refining is the high degree of mechanical development, of skillful arrangement of the whole plant, and the extensive use of labor-saving devices. It will be remembered how enthusiastically this point was emphasized by Prof. Haber in his report on electrochemistry in the United States, when discussing the Anaconda refinery. This high mechanical development has been of great influence upon the development of the refining industry in this country, for a consequence has been to concentrate the industry in not more than ten large plants. The reason for this situation is that smaller plants cannot compete with our larger plants, since for a small plant it would not pay to provide the highly developed mechanical equipment of the larger works.

On the other hand, it would be incorrect to assume that the excellence of the mechanical equipment alone explains the success of our copper refining industry. Hand in hand with the installation of improved machinery and apparatus, the engineers of the refineries of this country have carried on extensive investigations in the electrochemical side of the problem, although naturally very little has been published of the results thus obtained. The rule of thumb has long ago ceased to rule in our large refineries, and careful scientific investigation has been substituted for it. True, the modern theories of electrochemical science—and especially the electrolytic dissociation theory—may be said to have had little or no influence on these investigations and on the development of copper refining in general. Yet these investigations were made in a truly scientific spirit, and by modern scientific methods.

Like any engineering problem, the problem of the electrochemist of an electrolytic refinery is essentially a financial one, namely, if the conditions of operation are varied in all possible directions, under which conditions will the cost be a minimum? Considered from this point of view, which is the proper one for an engineer, the problem of the best conditions of the method of refining copper—which, from a purely scientific point of view, might be considered, perhaps, the simplest process in the whole of electrochemistry—appears quite complicated. There are a great many details to be considered, and the different factors which determine the final cost are so inter-related that it is very dangerous to arrive at conclusions concerning the final cost by taking into account only some factors and neglecting others.

Nevertheless, the only way by which research in this line can proceed, is to study each determining factor separately, to study the change of the conditions if this one determining factor alone is varied, while all others are kept constant, and to take up in this way all determining factors, one after the other. In this way Prof. Bancroft's recent investigation gives valuable information on the cost as function of current density and temperature. As to Prof. Bancroft's conclusions,

it is a fact that among engineers of refineries there is a very emphatic disinclination as regards covered tanks, so that a higher temperature than used as present is considered impracticable. On the other hand, we know of at least one large refinery which studied the problem of the most economical current density and temperature some years ago in a way similar to that of Dr. Bancroft, and we have reasons to assume that nearly all of our large refineries have made extended researches in this direction in the past. It may, therefore, be assumed that the current density used by the various refineries has been adopted as the one which, in the opinion of those in daily touch with the conditions, is the most economical one in each case. If this be true, then the fact that there is such a great difference between the current densities used by the different refineries, can only be explained by the assumption that the current density is so inter-related with the other factors which determine the final cost that in the different cases of the various refineries the cost becomes a minimum for considerably different current densities, because the other conditions are considerably different.

A detail of copper refining, though a very interesting one, is discussed in the admirable article of Mr. Benjamin Magnus, published in this issue, on contact resistances and current leakages in an electrolytic copper refinery. When our readers have analyzed the figures given in the article, they will appreciate the importance of this detail for every refinery, and, in fact, for every electrolytic plant, and we join the author in the hope that his article will stimulate some exhaustive experimenting by electrolytic refiners and others along the lines of contact resistances. Mr. Lawrence Addick's paper, also published in this issue, is particularly valuable on account of the exact information given in the diagrams on the influence of impurities in commercial copper and of the method of mechanical treatment upon its electrical conductivity.

ELECTRIC ENDOSMOSIS AND PEAT BOG.

When an electric current passes through an electric cell, concentration differences at the two electrodes are observed which are due to the different mobilities of the anions and cations, together with the effect necessarily combined with the electrochemical action at the electrodes. For instance, if we electrolyze copper sulphate between two copper plates, copper ions pass out of the electrolyte to the cathode and copper ions are introduced into the electrolyte from the anode; besides this there is a change of concentrations due to the different mobilities of the Cu and SO₄ ions. If a porous diaphragm were introduced between the anode and cathode—which, of course, would not fulfill any technical purpose—another phenomenon would be added to the concentration changes which are produced without diaphragms. This other phenomenon is commonly called electric endosmosis or cataphoresis, and consists in a bodily transfer of the electrolyte from one side of the diaphragm to the other. Some time ago we referred in these columns to a suggestive paper of Prof. Bancroft, read at the New York meeting of the American Electrochemical Society, in which he pointed out that it would be absolutely incorrect to neglect the effect of electric endosmosis in diaphragm cells, since its value may be very consid-

erable. He also pointed out that the material from which the porous diaphragm is made is of decisive importance, and that it would be incorrect to consider the diaphragm as inert. In view of the extensive use to which porous diaphragms are put in various commercial electrochemical cells, the problem should invite careful attention, not only from scientists, but from electrochemical engineers.

With a stationary diaphragm the phenomenon of electric endosmosis consists in the bodily transfer of the liquid from one side to the other. But this is not the proper way to describe the phenomenon in its most general form. The phenomenon consists in a relative bodily motion of the liquid against the diaphragm. If the diaphragm is stationary, the liquid moves, but if the diaphragm is movable it will move in a direction opposite to that of the liquid in the other case. The case of a movable diaphragm is not a purely theoretical conception; on the contrary, it is very often met with in practice. Slimes or solid pastes filled with a liquid represent movable diaphragms. It should therefore be possible to apply electric endosmosis to a separation of the solid particles from the liquid. That this conclusion is correct, is, in fact, shown by the experiments described in a paper read by Count Schwerin before the International Congress for Applied Chemistry, an abstract of which will be found in this issue.

The most interesting experiment of Count Schwerin is the application of electric endosmosis to the removal of water from peat bog. The latter problem is an extremely important one. Many countries, for instance, Ireland, are rich of peat bog, at present practically worthless, but which would represent a great increase of the national wealth if a practical method were found for removing the water from the peat. On account of capillary action, settling does not take place, and evaporation of the water would be far too expensive. A long series of processes have been proposed for the solution of this problem, but none has thus far been successful. We do not find anything in Count Schwerin's paper which would prove that the application of electric endosmosis really means the commercial solution of this problem, but we may emphasize that here a new method has been proposed, based on correct principles. The proposed application shows at least that the phenomenon of electric endosmosis is not merely a subject for scientific investigation, but might become of considerable importance for industrial purposes.

The experiment of Count Schwerin is very simple. Peat bog, containing 85 to 90 per cent of water, is placed into a perforated wire basket which serves as cathode. The anode is suspended in the peat bog. As long as the circuit is not closed, the peat does not lose any of its water, because it is held in its pores by capillary action; but when the current is turned on, the water begins to percolate through the wire basket. It is not stated that it is possible to remove all the water from the peat, nor are any data given concerning the financial side of the process. We may call attention to a possibility which should interest metallurgists, that this process might be commercially applied to the removal of water from slimes, which is often desirable in chemical or electro-

chemical work. The subject is certainly interesting and important enough to invite further study.

ELECTROLYTIC PRODUCTION OF COMPOUNDS

The Digest of United States patents prior to July, 1902, has already considered the patented art relating to certain standard applications of electrochemistry to industry. In the manufacture of caustic alkalis and chlorine, of chlorates and bleaching liquors, electrolysis holds, or is acquiring a dominating position, and in other lines, as the production of white lead and other pigments, it has capabilities which will attain equal recognition when the essential conditions for even and continuous work are known; for in these lines the peculiar advantages of the electrolytic procedure, the simplicity and certainty of operation, and the nice capability for adjustment of conditions, are of especial importance. Aside from these standard lines, there has passed the Patent Office an electrochemical miscellany—a series of patents whose chief present value lies in their suggestiveness, and the conception which their perusal gives as to the real breadth of the electrochemical field. The first installation of these patents is abstracted in the current issue.

CARBON CELLS.

The Synopsis of this issue gives abstracts of two articles on carbon cells, one by Prof. Lorenz, and another by Mr. Jone. It is well known that the present method of generating electrical energy from carbon by means of steam engine and dynamo is an extremely roundabout method, and necessarily of very low efficiency. For many years the production of electrical energy direct from carbon in a carbon cell has been the dream of electrochemical inventors. The idea in general has been to devise a cell in which the electrochemical reaction should consist essentially in the oxidation of carbon, just as the electrical energy of the Daniell cell comes from the change of zinc into sulphate. If all the chemical energy in the cell could be completely changed into electrical energy, the efficiency would be 100 per cent. The dream is so beautiful and the scheme is so simple, that it is a pity we are obliged to state squarely and fairly that we are now just as far from its realization as ten years ago.

There is, however, another method for changing the chemical energy of the oxidation of carbon into electrical energy. The scheme is to use an ordinary primary cell, and to regenerate the materials which have undergone a change during discharge, to their original condition by means of carbon. The total change of materials in a complete cycle, representing discharge and regeneration, should consist in the loss of carbon which has combined with oxygen from the air. For instance, in the Daniell cell the scheme would be to reduce the zinc sulphate of the discharged cell back to zinc by means of carbon. An application of this principle is the cell devised by Jone and described in the Synopsis, which, however, is identical with the cell which for some time was exploited sensationally in the newspaper press. While we at present refrain from any criticism of this special cell, we may say that attempts in this general direction seem more promising than the invention of what might be properly called a carbon cell.

THE OUTCOME OF THE ALUMINIUM LITIGATION.

In our last issue we published an abstract of the recent decision in the suit of the Electric Smelting & Aluminum Co. versus the Pittsburgh Reduction Co. over the Bradley patent. From a correspondent, who is not connected with either company, we received the following information:

"The Pittsburgh Reduction Co. and the Electric Smelting & Aluminum Co. have reached a friendly agreement on the Bradley patent, to the effect that the Pittsburgh Reduction Co. has paid damages to the Electric Smelting & Aluminum Co. for the aluminium made by the former company up to the present, and will work under license of the Electric Smelting & Aluminum Co. in future. There shall be no more litigation between the two companies, and the Pittsburgh Reduction Co. shall have the monopoly for the production of aluminium until 1909."

In order to confirm this information we wrote to the Pittsburgh Reduction Co. and the Electric Smelting & Aluminum Co., asking whether this information is correct, and received from Mr. Alfred H. Cowles, president of the Electric Smelting & Aluminum Co., the following reply:

"The information is entirely correct. The settlement also involves the Cowles Electric Smelting & Aluminum Co. at Lockport, continuing to deal in all grades of aluminium under conditions where they will be able to supply the market at very favorable terms. The license extended to the Pittsburgh Reduction Co., under which they will pay royalty, reaches only to the manufacture of aluminium and aluminium alloys, and not to other uses to which the Bradley and Cowles patented processes are adapted. The Electric Smelting & Aluminum Co., owning the Bradley patents, stand ready to encourage electric smelting on lines where these patents are applicable, and to grant licenses on favorable terms for specific uses wherever the protection of the Bradley patents may be of value to newly developing industries."

INTERNATIONAL ELECTRIC CONGRESS.

The preliminary programme of the International Electrical Congress, to be held at St. Louis from September 12th to 17th, 1904, has just been issued. The date set for the Congress is the week, 12th to 17th September, 1904. This is the week preceding the session of the great scientific congress appointed by the Universal Exposition. On this account many of those who attend the International Electrical Congress will probably remain to attend the International Congress of the Arts and Sciences.

In accordance with the present plan, members arriving via New York will be enabled to reach St. Louis via Niagara Falls on Sunday, September 11th. Members will also be invited to attend the dedication ceremonies of the National Bureau of Standards at Washington. It is hoped that arrangements may be completed whereby the President of the United States may then meet the members.

On the morning of September 12th, at 11 a. m., a general convocation of the International Electrical Congress will be called. On the four succeeding days, from the 13th to the 16th, inclusive, meetings of the eight sections of the Congress will be held simultaneously. On the final day, September 17th, a second general convocation will be called. Members returning from St. Louis to New York may elect to stop off at Chicago and at Niagara Falls.

As at present proposed, the International Electrical Congress will comprise three distinct features:

First—A Chamber of Delegates, appointed by the various governments, and essentially similar to the Chambers of Government Delegates at the International Electrical Congresses of Chicago in 1893, and of Paris in 1900. It would seem that sufficient material has been collected since 1900, calling for international action, to warrant inviting the various govern-

ments to appoint delegates, as before, to the International Electrical Congress at St. Louis.

Second—The main body of the Congress, divided into eight sections. These sections, together with the names of the officers, appointed by Prof. Elihu Thomson, president of the Committee of Organization of the Congress, are given in the following table:

Section.	Subject.	Chairman.	Secretary.
A	General Theory; Mathematical and Experimental	Dr. E. L. Nichols, Cornell Univ.	Dr. H. T. Barnes, McGill Univ.
B	General Applications	Dr. C. P. Steinmetz, Schenectady, N. Y.	Dr. S. Shelden, Poly. Inst., B'klyn
C	Electrochemistry	Dr. H. S. Carhart, Univ. of Mich.	Mr. Carl Hering, Philadelphia
D	Electric Power	Mr. Chas. F. Scott, Pittsburg.	Dr. Louis Bell, Boston.
E	Transmission	Mr. J. W. Lieb, Jr., New York.	Mr. Gano S. Dunn, Amperes, N. J.
F	Electric Light and Distribution	Dr. Louis Duncan, Mass. Inst. Tech.	Mr. A. H. Armstrong, Schenectady.
G	Electric Transportation	Mr. F. W. Jones, New York.	Mr. B. Gherardi, Jr., New York.
H	Communication Electrotherapeutics	Dr. W. J. Morton, New York.	Mr. W. J. Jenks, New York.

Third—Conventions simultaneously held, in connection with the Congress, by various electrical organizations in the United States. It is proposed that each section of the Congress may be able to hold its meeting under some plan of conjunction with the organization or organizations devoted to the progress of the work selected by that section. Steps have already been taken to enlist the sympathy of the various organizations, with a view to perfecting the details of co-operation at a later date. Prominent among the organizations from whom co-operation is expected are: The American Institute of Electrical Engineers, The American Electrochemical Society, The National Electric Light Association, The Association of Edison Illuminating Companies, The Pacific Coast Transmission Association, and The American Electrotherapeutic Association. It is also hoped to secure the participation of American scientific societies.

The Universal Exposition at St. Louis has signified its intention of affording ample facilities for the accommodation of the Congress in its halls on the grounds of the Exposition.

The Committee of Organization of the Congress is as follows: President, Elihu Thomson; vice-presidents, B. J. Arnold, H. S. Carhart, W. E. Goldsborough, C. F. Scott, S. W. Stratton; general secretary, A. E. Kennelly; treasurer, W. D. Weaver.

The Advisory Committee consists of Messrs. B. A. Behrend, C. S. Bradley, J. J. Carty, A. H. Cowles, F. B. Crocker, Louis Duncan, H. L. Doherty, R. A. Fessenden, W. J. Hammer, Carl Hering, C. P. Matthews, R. D. Merzhon, K. B. Miller, W. J. Morton, E. L. Nichols, R. B. Owens, F. A. C. Perrine, M. I. Pupin, J. W. Richards, H. J. Ryan, William Stanley, C. P. Steinmetz, L. B. Stillwell, J. G. White and A. J. Wurtz.

The plans of the Committee of Organization are to invite all interested in electricity and its applications to accept membership in, and to attend the Congress, if possible; to convene the Congress during the week set aside by the Universal Exposition for that purpose (12th to 17th, September); to report the meetings of the Congress, and to publish the Transactions subsequently, each member of the Congress to receive a complete copy thereof. The fee for membership has been fixed at \$5, the proceeds to be expended in stenographic and other expenses, incident to the conduct of the Congress, and in printing the Transactions. Applications for membership are to be sent to the general secretary, Dr. A. E. Kennelly, Harvard University, Cambridge, Mass.

ALUMINOTHERMICS.—Dr. Hans Goldschmidt, whose experimental lecture before the Chemical Society of Columbia University is reported on another page, will deliver another lecture before the American Society of Mechanical Engineers on December 3.

CONTACT RESISTANCES AND CURRENT LEAKAGES IN AN ELECTROLYTIC COPPER REFINERY

By BENJAMIN MAGNUS.

During the course of some experiments the object of which was to determine the additional cost of depositing a ton of copper due to the power lost in contact resistances, we derived the results given below, which I take great pleasure in presenting to the readers of *ELECTROCHEMICAL INDUSTRY*, with the hope that these figures will stimulate some exhaustive experimenting by electrolytic refiners and others along the lines of contact resistances.

Following are the results obtained on a tank which had mercury wells for all electrode contacts.

CONTACT RESISTANCES—MERCURY CONTACTS.

Date.	Current.	Tank Voltage.	Anode to Bus-Bar.	Cathode to Bus-Bar.	Anode to Cathode.	Anode Contact.	Cathode Contact.	Cathode Hanger & Bus-Bar.	Anode Hanger & Bus-Bar.	
4-1	4000	0.108	0.011	0.036	0.150	0.003	0.006	0.010	0.004	No. 1 Remark.
4-7	4000	0.180	0.007	0.030	0.130	0.004	0.006	0.005	0.008	" 2 "
4-12	4000	0.194	0.013	0.034	0.157	0.005	0.005	0.004	0.003	" 3 "
4-18	4000	0.185	0.014	0.030	0.150	0.005	0.004	0.002	0.003	" 4 "
4-23	4000	0.167	0.013	0.018	0.134	0.007	0.005	0.002	0.015	" 5 "
5-2	4000	0.190	0.028	0.014	0.144	0.005	0.005	0.002	0.019	
5-7	4000	0.261	0.038	0.014	0.178	0.006	0.005	0.002	0.038	
Av.	4000	3.197	0.018	0.032	0.150	0.005	0.005	0.004	0.009	

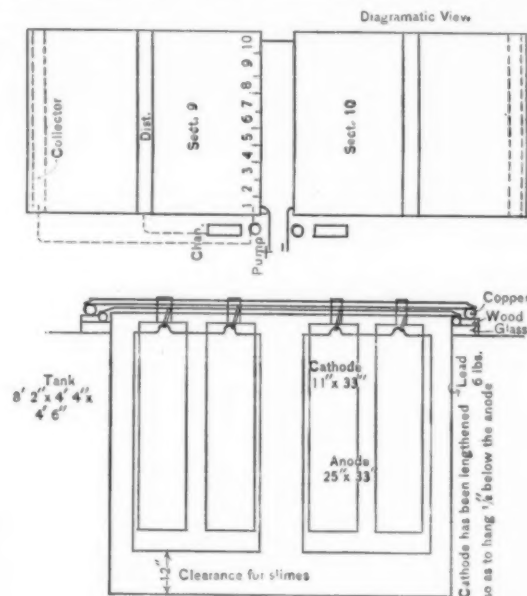


FIG. 1.—DIAGRAMATIC VIEW OF SUSPENDED ANODE AND CATHODE.

The average current density was 11 amperes per square foot.

The average temperature of electrolyte was 98° F.

No. 1. Remark—Before thin starting sheets were straightened.

No. 2. Remark—Serious short-circuiting of tanks, ampere efficiency only 88 per cent.

No. 3. Remark—Starting sheets straightened.

No. 4. Tank slightly grounded, initial voltage low, but contacts higher.

No. 5. Remark—Just before pulling, current density in anode about twice as high as at start of deposition.

These figures show what a low tank voltage it is possible to get, and when we add to the "Effective Voltage" (0.150) 0.007 volt due to drop across the slimes on surface of anode, we have 79.7 per cent of our energy effective in deposition

work which will be noticed as an improvement over the results obtained on a regular tank. But mercury contacts are impracticable.

Figure No. 1 shows a diagrammatic view of the suspended anode and cathode.

The anode is suspended by copper hooks from a copper-covered iron bar, which is the positive supporting bar. This bar rests on a positive bus-bar at each end.

The cathode is suspended by a copper hanger (fastened with a tinner's machine) from the negative supporting bar which has bus-bar contacts similar to the anode supporting bar.

Following the path of the current from the time it enters the positive supporting bar until it reaches the negative bus-bar we find the following contact resistances:



FIG. 2.—GENERAL VIEW OF ELECTROLYTIC REFINERY, SILVER MILL, POWER PLANTS AND CASTING PLANTS.

Current (amperes)	4000
Voltage per tank	0.230
Current density (ampere per square foot)	11
Energy in K. W.	0.920
Volts.	
Drop between the anode rod and the bus-bar.	0.0270
Drop between the cathode rod and the bus-bar.	0.0135
Drop between anode rod and anode hanger.	0.0060
Drop between cathode rod and cathode hanger.	0.0045
Drop between anode hook and anode.	0.0008
Total losses	0.0518
Per cent total energy lost in contacts.	22.5

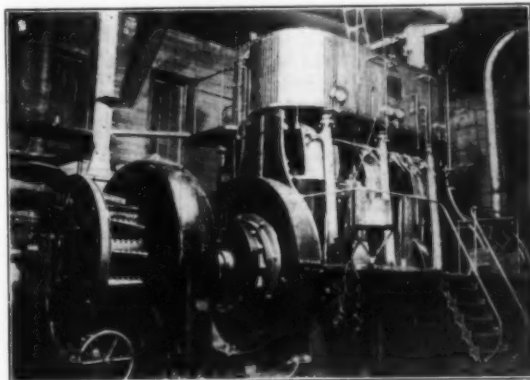


FIG. 3.—VIEW OF TRIPLE EXPANSION ENGINE COUPLED TO DYNAMO, BUILT FOR 3,600 AMPERES, BUT RUN CONTINUOUSLY FOR THREE YEARS AT 4,000 AMPERES.

These voltages are the averages of many readings. They vary according to the condition of the tank.

Below are the variations in ampere efficiency; in this case the value of the contact resistance is inversely proportional to the ampere efficiency. (This is not absolutely a condition which always exists).

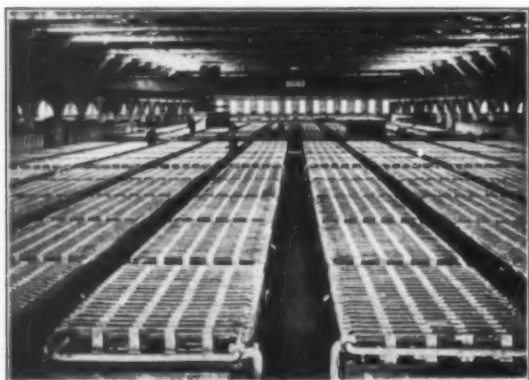


FIG. 4.—VIEW OF TANK HOUSE, EACH TANK PRODUCING 7,000 LBS. OF Cu PER MONTH.

DAILY INCREASE IN POUNDS AT BEGINNING AND END OF DEPOSITION.

Current Constant at 4000 amperes.

Average ampere efficiency of tank, 91.5 per cent.

BEGINNING.

	Weight.	Gain	% Amp. Efficiency.	% Total Energy Lost in Contacts.
April 10.....	1025			
April 11.....	1225	200	80.3	24.3
April 12.....	1435	210	84.3	23.8
April 13.....	1655	220	88.3	23.3

ENDING.

	Weight.	Gain	% Amp. Efficiency.	% Total Energy Lost in Contacts.
May 14.....	6728			
May 15.....	6945	217	87.1	23.2
May 16.....	7140	195	78.3*	25.0
May 17.....	7345	205	82.5	24.0
May 18.....	7549	204	81.9	24.0
May 19.....	7750	201	80.7	24.9

*Scrapped this day.

When the tank is first loaded, the cathode contacts have great resistance, but improve when the cathode acquires weight. The anode contacts are best when the tank is first loaded. On the 16th of May many light plates were hung in the tank dirtying the contacts with the result of high contact resistances and low ampere efficiency. This low ampere efficiency was caused by the light plates short-circuiting.

ANALYSIS OF TANK RESISTANCES.

Current (amperes)....4000
Current density (amperes per square foot) 11
Tank voltage 0.230 Volts.

Drop between anode and anode bus-bar... 0.0330
Drop between cathode and cathode bus-bar, 0.0180

	Volts.
Drop across electrolyte	0.1790
Per cent actual effective energy	77.8000
Per cent energy lost in contact and transmission..	22.1000
Per cent unaccounted for	0.1000

Total 100.0000

The drop across electrolyte (0.1790) means from surface of anode to surface of cathode, including the drop across the layer of slimes on the surface of anode, which is about 0.007 volts.

The percentage energy lost in contacts and transmission includes the contact losses, the transmission over bus-bars and supporting bars and the losses in passing current through the body of anode and cathode, but does not include the loss in leads from dynamo to tank.

The results of the tests on tank leakages conducted by Mr. F. I. Cairns, Met. Eng., and myself, are all marked on the drawing, and show the leakages from tank to tank, aisle to aisle, and tank to ground.

INSULATING PAINTS.

By MAXIMILIAN TOCH.

Twenty-five years ago insulating paints were virtually unknown, and with the introduction of electrical apparatus materials had to be employed for the purposes of protection, and a new field in the varnish and paint industry was opened. It is not the purport of this article to discuss the merits or demerits of insulating paints that are on the market, because the majority serve their purpose temporarily at any rate. Some are decidedly harmful, some are beneficial. All insulate to a greater or lesser degree.

The materials employed in the manufacture of insulating paints and varnishes consist principally of resins in a suitable solution. It is reasonable to suppose that no manufacturer who understands anything of the nature of the material would add a metallic element to the insulating paint, which would increase its conductivity, yet there are insulating paints on the market that are of such composition, and these are harmful to a great degree.

The principal gums that are used in making insulating varnishes are rosin, asphaltum, pitch, tar, kauri, manilla, shellac and copal. The principal solvents are turpentine, benzine, benzol, acetone, alcohol, bisulphide of carbon linseed oil, china wood oil, and in some instances water. Rosin is very largely

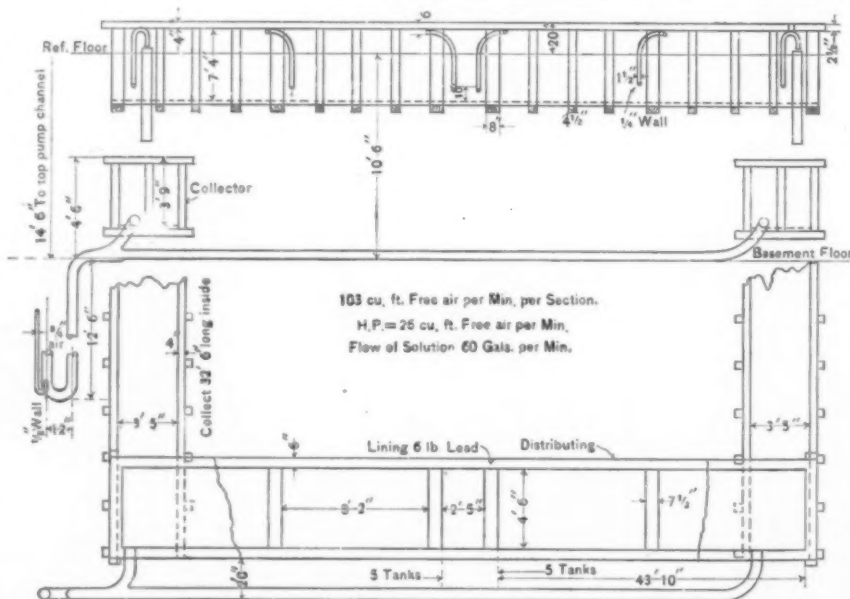


FIG. 5.—VIEW OF ONE ROW OF TANKS, SHOWING METHOD OF CIRCULATION.

used as a gum and on very fine work a solution of rosin alone is rather dangerous, because, being a very strong organic acid; it will corrode a copper wire in a very short time? The same may be said of tar. There is no one insulating paint which can be used for all purposes, but the nearest approach to this would be a paint which contains no rosin, is acid and alkali proof and will stand a fair degree of heat. Some factories buy a paint which they use for painting vats, smoke stacks, insulating wires generally, and which is cheap enough for all purposes, and good enough for any purpose.

Many electrical concerns, however, depend upon the manufacturer of these paints to supply them with an article which is made by a chemist who has sufficient knowledge of electricity to know to what uses the material is put.

THE TECHNICAL IMPORTANCE OF CATALYSIS.

G. BODLAENDER presented an interesting address which enumerates the various cases in which catalysis has found technical application. Since it does not permit of further abstraction, nor deals with any electrochemical questions, a complete report may be dispensed with.

THE ABILITY OF RHODANIC IONS TO FORM COMPLEX COMPOUNDS IN COMPARISON WITH THAT OF HALOGEN IONS AND CYANIC IONS.

A paper on this subject was read by H. GROSSMANN. According to Abegg and Bodlaender's theory of electro-affinity, the tendency of an ion to combine with other ions or neutral bodies to form complex ions is a measure of its "strength," i. e., the force with which it holds fast its ionic charge. The

weak cyanic ion forms complex ions most readily. After that comes iodine. Chlorine goes into complex ions with difficulty and fluorine not at all. The speaker showed that with respect to its ionic "strength" the rhodanic ion lies between iodine and bromine. It forms complex ions less readily than iodine, and more readily than bromine, and we have the following order; F, Cl, Br, SCN, I, and CN. Then follows a list of reasons in support of this view, especially the solubility of HgSCN in the various alkaline haloides.

The discussion dealt principally with the details of the investigation. Abegg called attention to the fact that the tendency to form complex compounds cannot always be determined from the amount of hydrolysis. The hydrolysis depends on the dissociation constant of the acid and this does not always run parallel with the formation of

complexes. For example, acetates have much less tendency to form complexes than oxalates, although the latter have larger dissociation constants.

SESSION ON THE AFTERNOON OF JUNE 6.

THE PRACTICAL APPLICATION OF ENDOSMOSIS AND THE COLLOIDAL STATE.

A paper on this subject was presented by BREDIG. It is well known that when the cathodic and anodic parts of an electrolytic cell are separated by a diaphragm, the liquid is very often forced through the diaphragm by the action of the electric current. We must distinguish between those cases in which the liquid passes through unchanged, and those in which a change of concentration takes place. The first case is called endosmosis or cataphoresis. The speaker gave the historical development of our knowledge of electrical endosmosis. G. Wiedemann found that the amount of fluid driven through a diaphragm by electrical endosmosis in the unit of time is proportional to the current density and independent of the thickness and cross-section of the diaphragm. The speaker called attention to the analogy of electric endosmotic phenomena with resorption in living organisms, brought out by the investigations of Cohnheim and others. G. Quincke showed that by means of the electric current fluid can be driven through capillary tubes and that a diaphragm can be considered as a number of capillaries lying side by side. He

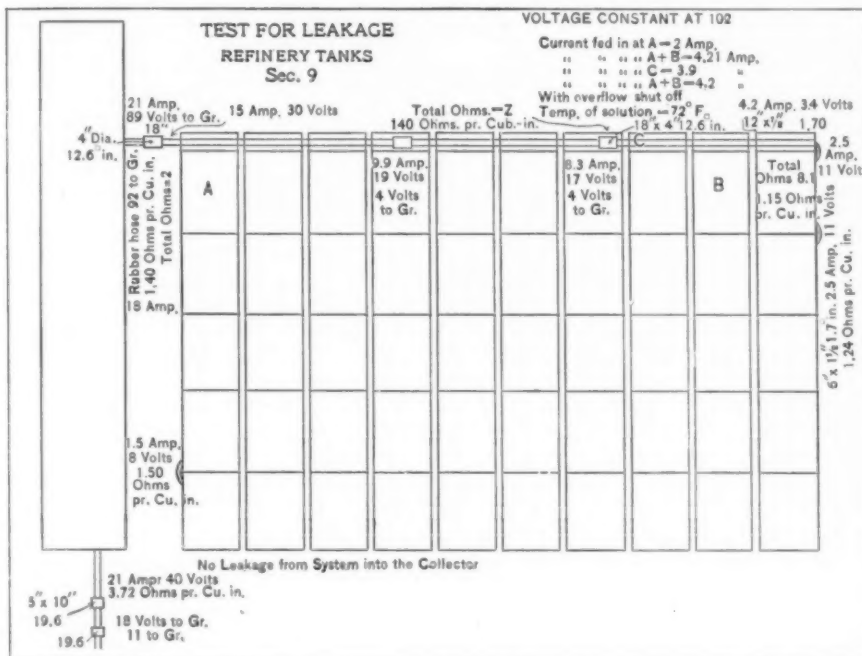


FIG. 6.—TEST FOR LEAKAGE—REFINERY TANKS.

INTERNATIONAL CONGRESS FOR APPLIED
CHEMISTRY.

Report of the Proceedings of Section X.
(Electrochemistry and Physical Chemistry.)

BY H. DANNEEL, PH. D. AND J. K. CLEMENT.
(Concluded from page 543.)

After the session on June 5, afternoon, Prof. Marckwald, of Berlin, delivered an interesting address on radio-active substances. He performed a series of lecture experiments with radium preparations, and also with radio-tellurium, which he himself discovered. Radio-active bismuth, which is obtained from pitchblende, is precipitated as a chloride with SnCl_2 . The precipitate thus obtained contains 90 per cent ordinary tellurium. This is converted into its chloride and treated with hydrazin hydrate, which separates out the inactive tellurium, while the radio-tellurium remains in solution. The latter is again precipitated with SnCl_2 . In this way from 4000 kilograms of pitchblende a few milligrams of the pure radio-tellurium may be obtained. This radio-tellurium occasions unusually strong fluorescence. The speaker performed a number of the usual lecture experiments with his preparation.

The following papers by Bodlaender and Grossman were presented in the morning session of June 6; the other papers read in this session having been reported in our October issue, pages 509 to 512.

also showed that both the amount and the direction of electrical endosmosis depend on the nature of the liquid, and on that of the diaphragm. The movement of suspended particles by the electric current is a special case of electrical endosmosis. There is no essential difference between this and the more general case. In the latter case the diaphragm is stationary, and the fluid moves; in the former the fluid remains at rest and the suspended particles migrate toward an electrode. Quincke found that platinum, gold, copper, iron, graphite, quartz, feldspar, manganite, asbestos, emery, burnt clay, kaolin, bubbles of oxygen, hydrogen and air, sulphur, silk, cotton, starch, lycopodium, carmine, paper, quills, ivory, oil of turpentine, carbon disulphide, carbon dioxide, and ethylene, when suspended in water, move in the direction opposite to the current, i. e., towards the anode. Suspended in turpentine oil, most substances with the exception of sulphur, move in the direction of the current. Thus, the nature of the fluid and of the suspended particles determines the direction of the latter's movement. Quincke's theory for the phenomenon is that there is a difference of potential between the liquid and the diaphragm or suspended substance, and that, if the suspended particles have a positive charge, e. g., with respect to water, they must move towards the negative pole. According to Quincke the velocity of the motion is proportional to the current density.

Helmholtz then formulated a complete mathematical theory of electrical endosmosis, and of the reverse of the phenomenon—the so-called "diaphragm current," discovered by Quincke. If by means of an electric current we can bring about a motion of the charged particles with respect to the fluid, vice versa by pressing a liquid through a diaphragm, we can generate an electric current.

Coehn formulated an empirical rule for the sign of the charge. According to Coehn's rule the medium with the higher dielectric constant is always charged positively with respect to the other. With respect to water, which, with the exception of HCN and H_2O_2 has the highest dielectric constant, the suspended particles are, as far as we know, mostly negatively charged and move towards the anode. Nernst says in regard to this point that each of the layers enveloping the two heterogeneous substances at the point of contact contains ions, and that the coefficient of distribution between the two mediums is different for every ion, so that a separation of the ions results. The explanation of Coehn's rule is that the solubility of the ions in the different mediums is closely connected with the dielectric constants of the latter. According to Knoblauch the latter depends also on the velocity of the diffusion of the ions from the one medium into the other.

Nernst has emphasized that a very important and fundamental question which has not yet been satisfactorily answered is here involved—the question of the origin and of the absolute value of the differences of potential between mediums in contact with each other. Small quantities of impurity, if they cover the surface of contact, can, even in very thin layers, cause a complete reversal of the phenomenon. In close relation with the phenomena of electrical endosmosis, and perhaps of equal importance, is the migration of colloids with the electric current. Colloidal solutions of arsenic sulphide, antimony sulphide, copper sulphide, cadmium sulphide, silver, gold, platinum, aniline blue, indigo, fuchsine, tannin, caramel, starch, haemoglobin, mastic and gamboge go towards the anode; ferric hydroxide, methyl violet, Hoffman's violet, and magdala on the other hand go to the cathode. Since the heterogeneity of such colloidal solutions is made probable, or, perhaps, certain by a number of their properties, colloidal solutions can be considered as a suspension of ultra-microscopic particles and then every difference between the migration of colloids and actual electrical endosmosis disappears.

It is interesting that the direction of migration of certain colloids, e. g., albumen, is changed by slight variations in the composition of the fluid. The direction in an acid solution is,

for example, opposite to that in alkaline solution. There must, therefore, be a certain concentration of hydrogen ions at which albumen no longer migrates by electric endosmosis and the albumen molecules have no potential difference with respect to the medium. According to Hardy, the discoverer of this phenomenon, albumen can be most easily coagulated at this point. This result of Hardy's requires further confirmation. It is well known that colloids are very easily coagulated with electrolytes. Quincke says that there is no connection between coagulating action and electrical conductivity, but to any one who has made similar experiments, the distinct difference between the precipitating action of electrolytes and non-electrolytes is unmistakable.

Hardy found that suspensions and colloids which move toward the anode are precipitated especially easily by cations, while those which move toward the cathode are precipitated more readily by anions. According to Schulze the precipitation takes place the more readily the greater the valency of the ion in question, and according to Spring the migration velocity of the ion is a joint factor.

In conclusion the speaker referred to an attempt of his own to connect the facts of the electrical opposition between suspension and fluid with the phenomena of coagulation, sedimentation, absorption and capillarity. Whitney and Billitzer found that in the coagulation of certain colloids by means of various salt solutions products of the electrolytic dissociation of the salts are formed in equivalent amounts. This would indicate electrolysis in accordance with Faraday's law. The circumstances connected with the coagulation of suspensions closely resemble the phenomena which Palmar observed with drop electrodes. The speaker believes that coagulation is most intimately connected with capillary electric phenomena. The relation between chemical composition and surface tension at the boundary of two mediums is of fundamental importance.

REMOVING WATER FROM PEAT-BOG BY ELECTRIC ENDOSMOSIS.

Following Prof. Bredig's address, COUNT SCHWERIN demonstrated a number of experiments bearing on the technical application of endosmosis.

If by the application of an external electrical potential difference a fluid can be made to pass through a porous earthenware cell or any other material which has a different dielectric constant from that of the fluid, then, on the other hand, particles suspended in the liquid must move through it. This phenomenon can be utilized in a number of cases in which it is difficult to remove the suspended particles from the liquid. There are, for instance, precipitates which cannot be filtered, and which require a long time to settle. By passing an electric current through such a suspension the suspended particles can be deposited in a firm layer on one of the electrodes. The speaker performed several experiments. A liquid suspension consisting of 20 per cent alizarin and of clay and peat was contained in a lead dish. An electrode of sheet zinc dipped in the liquid. By making the dish the cathode and the zinc electrode the anode, the suspended substance was deposited so firmly on the zinc plate that it could only with difficulty be cut away with a knife. It is possible in this way to almost free the water of the suspension. This process might be applied technically in removing water from peat-bog.

On account of the dirt, stone, earth, etc., which it contains, peat cannot be used as fuel for many purposes without being worked over. It must therefore be ground and washed. The product of the washing is a slimy mass which is very difficult to free from the 85 to 90 per cent of water which it contains. Filtration is impossible; peat does not settle; and evaporation of the water would cost more than the peat is worth. The peat sludge can be freed from the greater part of its water by electric endosmosis. When the sludge is placed in a wire net which is fine enough to keep the particles of turf from passing through, the water does not run off on account of adhesion. When a sheet of metal is laid on the sludge above

the wire net and connected to the positive pole of an electric circuit, and the net connected to the negative pole, the peat moves toward the metal plate and the water in the vicinity of the wire net is freed from the peat so that it can run off freely. The speaker performed the experiment. So long as no current flowed the wire net appeared to be watertight, but immediately on closing the circuit the water ran off rapidly. A similar but smaller apparatus, containing alizarin paste, acted in the same way.

In the discussion which followed, PROF. LUNGE, of Zürich, remarked that the dephlegmation of peat is a very old problem, and on account of the large deposits of peat on the earth, a very important one. This is a new illustration of how great scientific results can arise from apparently abstract theoretical researches. Replying to an inquiry the author remarked that after having treated peat by this method, 65 to 70 per cent water still remains. Suchy inquired whether the amount of water removed corresponds to a sort of Faraday's Law. Schwerin, Bredig, Coehn and LeBlanc cited examples showing that with one and the same material the amount of water removed is proportional to the quantity of electricity which is passed through, but that the amount of water corresponding to a given number of coulombs varies with the nature of the suspended substance, and with the size and shape of the grains.

In reply to an inquiry of Nernst's, Mueller von Berneck stated that electrolysis with the evolution of hydrogen and oxygen takes place, but that the two volts required for the electrolysis are of no consequence compared to the pressure required for dephlegmation, since 4 or 5 volts are required per centimeter of peat deposit. Freyss remarked that ore slimes can be freed of water by this means. Lunge called special attention to the working of gold fields where the slimes are often the source of great inconvenience.

CATALYSIS.

Then followed a lively discussion of the papers of Schenck, Bodenstein and Bodlaender on gas reactions in the presence of a catalytic agent. Schenck had discussed the decomposition of carbon monoxide in the presence of iron, Bodenstein and Bodlaender the formation of SO_2 from $\text{SO}_3 + \text{O}$ in the presence of finely divided platinum. The point at issue was whether it is permissible to deduce the order of such reactions from the reaction velocity. The discussion furnished a number of instigations for further investigation, but for the present it is outside of the field of electrochemistry, and as no decision was reached, a mere reference will suffice. The discussion is printed in detail in the *Zeit. f. Electrochemie*, Vol. IX., p. 742-751.

WINES CONTAINING GYPSUM.

MAGNANI read a paper on the inversion velocity of sugar in solutions of wine and gypsum. It has been asserted that in wine which contains gypsum, acid salts are formed which are injurious to health. The presence of acid salts would greatly accelerate the inversion of sugar. The speaker found that in a great number of wines no acceleration takes place and claims therefore that wines containing gypsum are not injurious to health.

CATALYSIS.

SABATIER read a paper on the addition of hydrogen (to organic compounds) by catalysis. Sabatier and Sendernes have found that when acetylene is passed over metallic nickel it is readily polymerized. When hydrogen and acetylene are passed over nickel together the acetylene combines with the hydrogen to form saturated hydrocarbons. These researches were published last year in *Comptes Rendus*.

The following experiments are of technical importance. The speaker was successful in obtaining the reduction of nitroderivatives, the synthesis of naphthene, and the conversion of aldehydes and ketones into alcohols. The metal acts catalytically, but its catalytic action is destroyed by the presence

of traces of impurities, e. g., when the hydrogen contains arsenic or sulphur.

THE ROLE OF THE CATHODE MATERIAL IN THE REDUCTION OF NITROBENZOL

LOEB presented a paper on this subject and described experiments made in conjunction with R. Moore. The principal product of the electrolytic reduction of nitrobenzol suspended in aqueous solutions of caustic soda on platinum, nickel and mercury cathodes is azoxybenzol; on lead, tin or zinc electrodes, also on copper cathodes, especially when copper powder is present, anilin is formed. The object of their experiments was to ascertain what role the cathode material plays in these reactions, to determine whether the reduction energy depends simply on the potential of the cathode, and which ions perform the work of reduction.

The author first measured the potentials of the various metals in dilute sodium hydroxide by different current densities and then the same in the presence of nitrobenzol. The difference of the two values by a given current density they designated as the "depolarization value" of nitrobenzol for this density. The "depolarization values" for platinum and most of the metals which are attacked by chemical action were found to decrease with increasing current density. An explanation of this phenomenon is that, with increasing strength of current, the reduction velocity of nitrobenzol increases because of a greater number of reducing ions arriving at the cathode. As these ions are held back in the electrolyte by the process of reduction their osmotic pressure increases while the electrolytic "solution pressure" does not essentially change. Thus with rising current density the depolarization values decrease. The depolarization curve for copper, on the other hand, shows periodic fluctuations. With increasing current the curve alternately rises and falls. The probable explanation for this is that nitrobenzol is very slowly reduced by copper, and the resulting phenylhydroxylamine very rapidly.

At the beginning of the experiment copper is deposited on the cathode, and since the osmotic pressure of the copper ions is thus diminished the "depolarization value" rises. As soon as the hydroxylamine phase has reached a certain value the dissolution of the copper sets in with great rapidity; the osmotic pressure of the copper ions rises and the "depolarization value" falls. When the phenylhydroxylamine has been used up the opposite effect sets in. This process goes on repeating itself periodically.

It follows from the experiments that the specific action of metals can be regarded as electric potential action, and that by artificially maintaining a constant electrode potential the same reduction process could be obtained on any electrode. This standard potential is not as has always been assumed the absolute cathode potential, but the "depolarization value," and it varies with the current density. It has been experimentally proven that in the same electrolyte, and by the same temperature on different attackable and non-attackable electrodes kept at constant potential the same products can be obtained and in almost equal yields.

SESSION ON JUNE 8.

ELECTROPLATING PLANTS.

Under the title "Installing of Electroplating Plants," SACKUR talked about improvements in the arrangements of works, e. g., about new processes for nickel-plating, zinc, for removing tin plate. He spoke about dynamos, electrical measurements, composition of baths; about grinding machines, boiler plants, etc., and finally described in detail a plant which he had erected himself.

QUANTITATIVE DEPOSITION AND SEPARATION OF METALS BY ELECTROLYSIS.

A paper on this subject was presented by NISSENSON AND DANNEEL. A number of methods were described which have stood the test of practice, and the determination of Pb, Cu, Sb, Sn, Co, Ni, Zn, and Cd was discussed by Nissenson. Dan-

neel discussed the questions under what conditions are metals at all deposited and under what conditions are they deposited in a compact, weighable form. The first question is completely answered by Nernst's formula. To apply the latter, besides knowing the "solution potentials" of all the metals (their "single potentials" in a solution which is normal with respect to the metal in question), one must know the ionic concentrations in the solutions out of which the metals are to be deposited. We know the "solution potentials" of most of the metals, but we know almost nothing about the ionic concentrations in most of the solutions which are used in practice. To supply this knowledge is the most important problem of electro-analysis. Until this has been done electro-analysis will continue to be an empirical art.

Concerning the question as to the conditions under which metals are deposited in compact, weighable form, we have as yet only empirical conceptions. Metals are said to be best deposited when the separation is the result of a secondary reaction. The speaker is of the opinion that secondary separation takes place only in a very few cases. The evolution of hydrogen by the electrolysis of potassium chloride solutions is generally said to be a secondary reaction; a simple calculation with Nernst's formula shows that in order to separate out potassium before hydrogen there would have to be 10^{10} kg. of potassium ions per liter.

The author develops the following picture of the deposition of metals. Consider a rough electrode, with projections and cavities in a solution of $\text{AgK}(\text{CN})_2$. Since electric current always follows the lines of least resistance, and the metals offer less resistance than the electrolyte, the current lines will converge toward the raised places. Consequently these points will be impoverished of silver ions, the voltage required to separate out the metallic ions then increases in accordance with Nernst's formula and these paths are no longer the lines of least resistance so that the current lines bend toward the deeper parts of the electrode until impoverishment of silver ions occurs again, and so on. The result is that with medium current density the current lines will be uniformly distributed over the surface of the electrode, and that the coating will be, therefore, uniform. The exceptions to the above, and the difference between complex and simple salts are apparent from the following consideration.

Impoverishment of metal ions is produced (a) in all solutions by the liberation of metal ions; (b) in all complex salts by the increase of the ions of the salt which forms the complex compound with the metallic salt, e. g., of CN ions, in $\text{AgK}(\text{CN})_2$ solutions, by which according to the law of chemical mass action the concentration of silver ions is diminished:



(c) in all complex salts which form complex anions containing the metal to be deposited, the latter are carried away by the current from the cathode.

Impoverishment of metallic ions at the cathode is counteracted by:

1. Diffusion is greatest where impoverishment is greatest, and where the cross-section of the diffusion lines is greatest; i. e., on edges and corners.

2. Ions resulting from fresh dissociation. As long as the dissociation velocity is very small compared with the velocity of the other processes which furnish or carry away ions—this can be assumed to be the case with all good depolarizers—the furnishing of fresh ions by dissociation does not influence our considerations.

3. In simple salts and in those complex salts which form a cation containing the metal in question, the current brings new metal ions to the cathode, and the effect is greatest where the number of current lines is a maximum.

4. Local currents. If the impoverishment on the electrode is not uniform, short-circuited concentration cells will be formed on the electrode, and these will neutralize the impoverishment. This really means that the distribution of the

current lines over the surface of the electrode tends to be uniform.

The difference between complex and simple salts is: With complex salts which contain the metal in the anion $a, b, c, 1$ and 2 act and a uniform deposit will be here most readily obtained. In complex salts which contain the metal in the cation $a, b, 1$ and 2 act. In simple salts $a, 1, 2$ and 3 act, and an uneven deposit is therefore most likely to occur in simple salts. This explains why a better deposit of silver is obtained from a potassium cyanide solution, than from silver chloride.

If the current density is so small that there is sufficient time for diffusion to prevent considerable impoverishment of the ions near the electrode, there is no longer ground for the current lines not conveying towards the highest points of the electrode, and the metal grows into large, well developed crystals, as, for example, in a silver voltameter at small current densities. On the other hand, with current densities at which the processes counteracting the impoverishment of metal ions are unable to fully prevent it, the metal will be uniformly deposited. If this were not the case we should never be able to obtain a smooth metallic coating. With increasing current density the ionic concentration at the electrode becomes less. When the latter falls below a value which makes the potential at which the metal is separated out equal to the decomposition voltage of hydrogen we obtain a loose, spongy, crystalline metal due to hydrogen being simultaneously evolved. A spongy deposit is especially easy to obtain with metals which form alloys or compounds with hydrogen, e. g., silver, gold and platinum.

In the discussion Foerster expressed the same opinion about our slight knowledge of analytical electrochemistry. The methods which are already known should undergo a thorough, systematic rearrangement. Bodlaender thought that the question as to whether a metal is primarily or secondarily precipitated could not be decided from Nernst's formula. There might be other phenomena such as the formation of alloys, for example in the "over-voltage" of hydrogen, which cause a precious metal to be precipitated before a base metal.

LOW TEMPERATURE RESEARCHES.

G. MONTI presented a paper on industrial applications of the concentration of solutions by freezing and the production of low temperatures by the action of concentrated solutions on ice. He tried to concentrate the poor wines of 1901 by freezing them. He found that the concentrated solutions, instead of accumulating in the center of the block of ice, collected between the small ice crystals. He described his method for continuously extracting the wine from the ice crystals. He also described a number of simple methods for producing the low temperatures which he required.

POLISHING CARBON PLATES AND THE LIGHTING OF IONS.

VON BOLTON presented a paper on the emission of light by the ions. If a carbon electrode which is connected with the positive pole of a battery (giving about 110 volts) be dipped in sulphuric acid, another electrode completing the circuit to the negative pole, a layer of oxygen is formed about the carbon electrode. The oxygen is pierced by numerous small electric arcs and emits a bright yellow light. If, after some time the electrode is removed, it will be found to be brightly polished. The firm of Siemens & Halske has patented this process for polishing carbons. Metals behave similarly to carbon when connected to the positive pole, and their surfaces are polished. When metals are used as the negative electrode they emit a different light, the color of which varies with the nature of the metal. Copper, for example, emits a green-blue light, lead violet, aluminium green, magnesium blue-green, etc. The metals of the platinum group Pt, Ir, Pd, Rh, and Ru all light in different colors: Pt violet, Ir and Pd green. The speaker thinks that the ions produce the light as, at the moment of liberation, they pass through the layer of oxygen. Most beautiful spectra can be obtained from this light. Spectra of the alkaline earth metals obtained in this way are better and

stronger than those obtained from a spark between a solution and a platinum point.

The ionic spectrum of strontium shows seven brilliant lines in the green which are scarcely to be noticed in the spectrum from the ordinary spark.

Spectra of metals which are not attacked when exposed to the air can be obtained by dipping them in HNO_3 , which is diluted with four parts of water. The acid solution is contained in a spherical glass vessel. An open glass tube, in which the negative electrode is suspended, is introduced through an opening in the top of the sphere. It reaches almost to the bottom of the tube and separates the negative electrode space from the positive, thus avoiding the formation and explosion of oxyhydrogen gas. The metal to be investigated is attached to the negative electrode.

The aluminium spectrum which was exhibited by the author is characterized by remarkable, broad bands in green and blue and extending into violet. It appears as though one were looking into hollow half cylinders which were dissected perpendicular to their axes and apparently illuminated from left to right. A number of other metals have similar "cylinder bands." These "cylinder bands" differ considerably from ordinary spectrum bands. For example, the magnesium "ionic spectrum" has two green "cylinder bands" whose illumination is opposite to that of aluminium, i. e., from right to left, from the violet end of the spectrum to the red.

The author uses a similar but smaller apparatus to investigate the "ionic spectra" of dissolved salts. A platinum wire serves as negative electrode. With this apparatus extraordinarily small quantities of salts can be qualitatively determined, e. g., 1 milligram NaNO_3 in 10 Liter H_2O gives a good test for sodium. One milligram thallium nitrate in 1 liter H_2O gives the green thallium lines very clearly. After three washings with distilled water and filling with NaNO_3 , the green thallium lines could still be distinctly seen. The test for strontium is just as delicate.

In the discussion which followed, Elbs inquired if it were possible that carbon compounds were formed on the polished carbon electrode, and that these cover the electrode with a glossy varnish, the carbon being sticky after the experiment. Von Bolton said he has made no experiments in this direction. The fact that the electrolyte becomes turbid and black would indicate that the carbon pulverizes and dissipates in powder form through the electrolyte. It may be that graphite is formed on the surface of the electrode. Coehn asked whether a precipitate is deposited on the cathode after the electrolyte has become black. Such a precipitate could be attributed to the carbon being dissolved at the anode and separated out at the cathode. Von Bolton replied that he had obtained a black deposit on platinum cathodes, but did not know whether it was carbon. An excellent carbon precipitate is formed on aluminium cathodes, even when the solution has been filtered and the suspended particles removed. Coehn concludes from this that the carbon is electrolytically dissolved and precipitated in accordance with Faraday's law.

Arnot thought that the color phenomena which Bolton had observed were not due to the emission of light from the ions, but to the pulverization of the metals. The small metallic particles were vaporized by the high temperature and the colored light was emitted from the metal vapors. Von Bolton replied that if this were true the same light effect should be obtained with metallic anodes, but this is not the case, although the temperature at the anode is higher than at the cathode. If the light were due to metallic vapors, the oxide spectrum ought to be visible. Furthermore Bolton thought it impossible for the ions to be first discharged and then to emit light as molecules.

Martens thought that Bolton's apparatus was like the Wehnelt interrupter. The latter works quite differently when the poles are reversed and therefore it is to be expected that when the poles in Bolton's apparatus are reversed the light

effect will be different. He asked whether the method could be applied to spectrum analysis. Bolton replied that with some metals one obtains all the lines which appear in the ordinary spectrum, with some metals less than in the ordinary spectrum and with others more. All disturbing extra lines, such as, for example, those caused by the air in the spectrum from an electric spark, are absent from the "ionic spectrum." The metallic spectra obtained in this way are always pure. With most metals, Zn and Cd excepted, the $\text{H}\alpha$ line is obtained.

In reply to Martens, who said that he did not believe the method was of any practical value, Von Bolton replied that he made mixtures of different salts and obtained all the lines of the components, he found that the addition of sodium often raised the brightness and brilliancy of the spectrum. If one takes brass or a nickel coin and treats it according to this method, one will immediately see the copper and nickel spectra. The nickel lines will be weaker than those of copper. With zinc and copper all the lines of both spectra can be seen wonderfully clear. As zero point he has always taken the $\text{H}\alpha$ line of the hydrogen spectrum taken from a Plucker tube.

ELEMENTARY THEORY OF ELECTROLYSIS OF SODIUM CHLORIDE WITH DIAPHRAGMS.

A. GUYE presented a paper on this subject. F. Foerster and his scholars have shown that the output of sodium hydroxide by the electrolysis of alkaline chlorides with diaphragms at any instant is given by the equation $r = 1 - nx$ in which n is the "transport number" of the alkali and x is that fraction of the unit of current which is transported by the alkali. x is a function of the electrical conductivity of the alkaline chloride and of the hydroxide, or, what amounts to the same thing, of the concentrations c and C of alkaline chloride and hydroxide, and of the temperature. A more careful study of the changes of r shows that, under the conditions of experiment which generally underlie technical electrolysis, r may be considered as a function of a single independent variable, namely, the concentration of the alkali c (expressed in gram-molecules per liter).

We have then the equation,

$$r = f(c)$$

Under the assumptions it is easy to derive the fundamental formula for the course of electrolysis. When the quantity of electricity dF flows through the electrolyte rdF gram-molecules NaOH are formed in the cathode space. If we denote the volume of the liquid at the cathode with V the increase of the concentration is V dc gram-molecules of NaOH . These two quantities are equal:

$$rdF = Vdc \text{ or } dF = V \frac{dc}{f(c)}$$

or when we integrate from $F = 0$ to $F = m$ and from $c = 0$ to $c = c$:

$$m = V\phi(c)$$

in which $\phi(c)$ is the definite integral of the second term of the foregoing equation. Experiments in the Physical Laboratory of the University of Geneva have shown that for $r = f(c)$ we can substitute the expressions

$$r = \frac{1}{(a+c)^{\frac{1}{2}}} \text{ or } r = \frac{1}{a+c}$$

with sufficient exactness; the former when the cathode solution is saturated with sodium chloride, the latter when it is not saturated. Numerical verifications of these formulas both from laboratory experiments and experiments on an industrial scale show that the above elementary theory of diaphragm cells agrees very well with practice.

In reply to a question from Foerster, Guye explained that

the formula $r = \frac{1}{(1+ac)^{\frac{1}{2}}}$ applies to solutions in which the concentration of sodium chloride is constant. When the con-

centration changes according to Faraday's law, the formula

$r = \frac{i}{i + ac}$ is the one to be applied. The experimental results of Foerster and his students are all somewhat smaller than those calculated from the formula. Van't Hoff asked if a better yield could not be obtained by removing the hydrogen which adheres to the cathode, for example, by rotating the cathode, and thus reducing the resistance of the cell. Guye had obtained the same results with rotating cathodes as with stationary ones.

MANUFACTURE OF BISULPHIDE OF CARBON IN THE ELECTRIC FURNACE.

In the session of June 4, Mr. E. R. TAYLOR, of Penn Yan, N. Y., presented a paper on this subject. This was the only paper read by an American before the electrochemical section of the Congress. The author first discussed the disadvantages of the use of externally heated retorts for manufacturing bisulphide of carbon, and then described the type of electric furnace developed by him for this purpose. Since this furnace has been repeatedly described in *ELECTROCHEMICAL INDUSTRY* (October 1902, pp. 60, 63, 76), reference to our former description must here suffice.

The author said that his furnace gives the possibility of uniformly obtaining the most suitable temperature (very high, very low, or anywhere between) for any given furnace reaction, and maintaining the same without fluctuation for days, weeks or even months together. All materials, after having once been placed in the furnace, feed uniformly by gravity and fusion, giving such unity to the whole as to give the best possible results from an economic point of view. He has made in his furnace 15,000 pounds in twenty-four hours, and with more electric power in the same furnace, 25,000 pounds can readily be made in that time. The larger the furnace, the easier it can be worked.

ELECTROCHEMISTRY AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

A new laboratory devoted exclusively to electrochemistry was opened at the beginning of the school year at the Massachusetts Institute of Technology to provide facilities for the professional work in the senior year of students electing the schedule of electrochemical studies and for graduate students desirous of taking up this line of work.

Instruction in electrochemistry has been given to students in physics since 1894, but the recent rapid development of the industrial applications of the science determined the department several years ago to extend the work and to lay out a schedule of studies directed particularly to this end. This course was officially announced by the Institute in the summer of 1900.

In the new laboratory each student's desk is provided with a 2, 12½, 25 and 110-circuit, rheostat, stirrer, gas, water and suction. Besides an equipment for analytical work, each student is given a complete set of electrochemical measuring apparatus, including a Weston ammeter and voltmeter with three scales, Lippmann electrometer, potential boxes, conductivity bridges, voltmeters, etc. The whole class is thus able to work at the same time on subjects which are being concurrently discussed in the lectures, and thus, in conferences held weekly on the current work, to compare results of each other's experiences. The laboratory is also equipped with special arrangements for electrochemical analysis. Special rooms adjacent to the laboratory are equipped for measurements of electrical conductivity, dielectric constants, etc. Special generators have been installed to give direct or alternating currents for electrolytic and furnace work, and to allow considerable variations of voltage.

HISTORICAL SKETCH OF THE DEVELOPMENT IN THE PRODUCTION OF COPPER, NICKEL AND ZINC FROM CHLORIDE SOLUTIONS.

By WILLIAM KOEHLER.

(Concluded from page 542.)

In the year 1893 Dr. Carl Hoepfner came to America for the purpose of demonstrating his process to the Canadian Copper Co. A small experimental plant was then built at the above-named company's works at Brooklyn, Cleveland, Ohio, under the direction of Messrs. Hoepfner and Wannschaff. The process as here shown was carried on in much the same manner, and with the same apparatus as at the works of Mr. Throm in Giessen, Europe. Copper and nickel of good quality were produced and the feasibility, together with the practicability, of the production of metals from pure chloride solutions were demonstrated.

At this time Dr. Hoepfner did not limit himself to the production of copper and nickel as shown and demonstrated but claimed the possibility of the direct refining of these metals from chloride solutions, using copper-nickel anodes, or in case of copper alone, copper anodes making the process similar to the present refining of copper from sulphate solutions using crude metal anodes. In the case of nickel refining, nickel anodes were to be used in a neutral or slightly acid solution of nickel chloride.

In 1894 the experiments carried on by Dr. Hoepfner and Dr. Wannschaff on one side, and Mr. David H. Browne, representing the Canadian Copper Co., on the other side, terminated. Mr. Browne ceded the fact that good copper and nickel were produced, but that the process did not come up to the requirements of his company, and, therefore, negotiations towards installing a larger works came to a close. In the meantime the zinc process, as described in the *Eng. and Min. Journal*, May 16th, 1903, page 750, by Mr. Emil Guenther, was put into practical operation on a large scale at Furfurt, Germany. During the same year Messrs. Hoepfner and Wannschaff returned to Europe; previously, however, contracts were signed whereby the writer was to go to Europe in the interests of the copper and nickel industry. Preliminary experiments were immediately taken up at the electrolytic bismuth refinery by Mr. George Throm. The abandoned works of Blumrath & Schneider, at Weidenau, Siegen, were again fitted out for the purpose of demonstrations on a larger commercial scale than had been tried elsewhere.

At these works the sheet iron cathodes which had up to date been in use in the nickel electrolysis were replaced by sheet nickel cathodes. The form of the copper baths was changed from a triangular bath to rectangular vats of 3 m. x 1 m. x 1 m. (see Fig. 7), thereby conforming more nearly in size and external shape to the baths at present used in refining of copper from sulphate solutions. The circulation of the copper bath was materially changed and the rate of flow or speed of the anode electrolyte greatly increased. The baths were equipped with sixteen cathodes, each of 0.5 square meters active or submerged surface. The chlorine gas evolved in the nickel electrolysis was absorbed in a series of towers and vats by means of crushed matte and a solution of mixed chlorides. The towers were equipped with air ejectors. These ejectors keeping the whole system under a partial vacuum thoroughly prevented the escape or loss of chlorine gas. Another innovation introduced at this time was the application of a jet of superheated steam in the agitation of mattes in a cupric chloride solution, thus dispensing with revolving leaching drums.

The results obtained at Weidenau were of such a satisfactory nature that it was decided to enlarge these works. In order to obtain better facilities than were obtainable at Weidenau, the works were removed to Papenburg, and they are at the present time in a flourishing condition. In 1894 Dr. L. Mond began to take an active interest in the zinc and chlorine industry. Dr. Friedrich Mohr was appointed to thoroughly investigate the

technical side of the question, and after spending some time at Giessen, also at the zinc works at Furfurt, which were under the supervision of Dr. George Eschmann, it was decided to build a zinc bleach plant in England under the auspices of the Brunner Mond Alkali Co. Through the courtesy of Mr. H. Steinmeister, of the Gesellschaft für Metallelektrolyse mit Beschränkter Haftung, I am advised (Aug. 19th, 1903) that these works are now operating uninterruptedly with 1200 hp., producing an exceptional quality of zinc and bleach. Further, the copper nickel works at Papenburg are being increased by the addition of another unit of 600 hp. The power consumed at the Brunner-Mond works produce daily about 6000 kilos of zinc and 18,000 kilos of bleach, equalling 6 and 18 tons, respectively.

In the years following 1894, after Messrs. Hoepfner and Wanschaff had returned to Europe, Mr. David H. Browne, of the Canadian Copper Co., again took up the electrolytic production and separation of copper and nickel. Through the efforts of Mr. Browne, who associated with himself Mr. L. R. Vorce and Prof. Langley (Mr. Langley being professor of electrical engineering at Case School of Applied Science), the

Browne process was brought into existence. According to patents issued to Mr. Browne, filed in 1899, and granted December 2, 1902, we have the following L. P. 714,861, an invention which has for its object the improved separation of copper and nickel by electrolysis on a commercial scale.

In the annexed Fig. 3 is shown one form of apparatus adapted to be used in the Browne process.* Copper-nickel matte is treated by any suitable process to form copper nickel alloy substantially free from sulphur. From the copper-nickel alloy so formed are made in proportions dependent upon the relative amounts of copper and nickel therein contained copper and

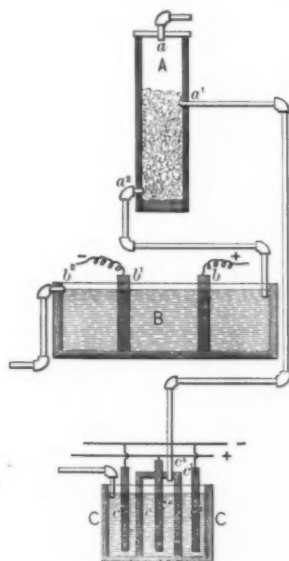
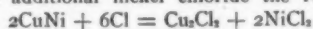


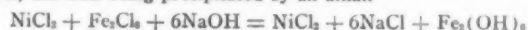
FIG. 2.—BROWNE PROCESS.

nickel anodes and copper-nickel fragments or powder.

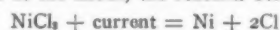
The copper-nickel fragments or powder are placed in the receptacle A, which designates the shot tower, and which is provided with apertures a, a' and a". Such subject matter is there subjected simultaneously to the action of a stream of a solvent for cuprous chloride, such as salt water introduced in the top of the tower at a, and a stream of free chlorine introduced at the side of the tower through the aperture a'. The combined action of salt water and of the heat produced by the combination of the chlorine with the copper nickel alloy, forms a solution of cuprous and nickel chlorides, the reaction being $2\text{CuNi} + 6\text{Cl} = \text{Cu}_2\text{Cl}_2 + 2\text{NiCl}_2$. Such solution is permitted to run out through aperture a" and thence into the electrolytic cell B containing an anode b of copper-nickel metal and a cathode b'. The electric current being passed through the solution of cuprous and nickel chlorides, the cuprous chloride is decomposed, the copper plating out upon the cathode, and the chlorine combining with the copper and the nickel of the anode forming cuprous chloride and additional nickel chloride the reaction being,



The cuprous chloride so formed is also decomposed in the same manner as was that of the original solution, cuprous and nickel chlorides being formed from the anodes as before and copper plating out. In this manner all the copper is plated out, and only nickel chloride remains which nickel chloride is permitted to emerge from the cell at b". The nickel chloride is now freed from any impurities such as iron or traces of copper, the iron being precipitated by an alkali



The liquor is then heated to a temperature of between 30° and 60° C., and is also increased in strength preferably to a density of from 30° to 50° Baume. It is thereupon introduced into a nickel plating apparatus which may consist of a series of cells such as C, each of which may have a porous diaphragm c and an anode cap c', a carbon anode c", a nickel cathode c', a chlorine escape c', connecting with aperture a' of the shot tower A. On the passage of the electric current through this latter solution, nickel is plated upon the cathode, and chlorine gas is liberated at the anode, the reaction being



Said chlorine gas is then conducted to the shot tower A and is utilized, as previously described, to form the solution of copper and nickel chlorides, the reaction being



Section 13 of patent claims reads as follows: "In the art of copper separation the process which consists in electrolyzing a solution of nickel chloride, plating out nickel therefrom and separating chlorine therefrom, treating copper nickel matte to form copper nickel alloy substantially free from sulphur, subjecting said alloy concurrently to said chlorine and a solvent for cuprous chloride, plating out copper therefrom and leaving nickel chloride solution substantially as set forth."

Before drawing a comparison between the Browne process and that of Hoepfner, attention is called to a statement in the above patent specification (line 55 to 65 L. P. 714,861). The patent distinctly states the cuprous chloride is formed (using copper and nickel anodes) in the same manner as that of the original solution, cuprous and nickel chlorides being formed from the anodes as before and copper plating out. In this manner all copper is plated out and only nickel chloride remains. The writer does not conceive how it is possible to remove copper completely from a solution when at the same time copper is being constantly introduced into the same solution through the electrolytic disintegration of a copper-nickel anode. If a copper-nickel anode be used, copper will always find its way into the electrolyte. The methods of prevention are either to electrolyze the copper-nickel chloride solutions with a nickel anode (containing no copper), thereby enriching the electrolyte in nickel contents, or to electrolyze the copper-nickel chloride solution in the same way as Hoepfner does with an insoluble anode, thereby plating out all the copper leaving the nickel contents of the electrolyte unchanged, and collecting the chlorine gas which will now be given off at the anode according to the reaction



The copper may also be chemically precipitated from the electrolyte. At the time that Hoepfner demonstrated his process at the Canadian Copper Co.'s works in 1893 and 1894 the old Swedish method of smelting copper-nickel ores to copper-nickel metal free from sulphur or any other smelting methods for the treatment of high-grade matte to form copper-nickel alloys were considered too expensive.

The cost of producing copper-nickel alloys from mattes therefore excluded a direct electrolytic process using copper-nickel anodes and an electrolyte of cuprous chloride in a solution of salt or calcium chloride. The experience gained from the Marchese electrolytic process using copper matte anodes, namely, the brittleness of such anodes, the uneven disintegration of the same, and, lastly, but not least, the separation of sulphur from such anodes when subjected to electrolysis, thereby

* An exact description of the Browne process as it was operated for several years successfully in Cleveland is given in *ELECTROCHEMICAL INDUSTRY*, July, 1903, p. 381 to 384.—Ed.

causing an abnormal rise in the potential of the bath, fully excluded the application of anode material carrying from 40 to 60 per cent metal in the Hoepfner process.

The raw material used in the Hoepfner demonstration consisted of from 40 to 60 per cent matte. The best method of comparing the Browne process with the Hoepfner process seems to lie in the comparison of the chemical reactions entering into each. The following reaction, as given to the writer by Dr. George Wannschaff in 1893 and 1894, while this gentleman was demonstrating the Hoepfner process at the works of the Canadian Copper Co., clearly demonstrates the process on a broad and liberal basis:

- (1) $x\text{CuNiS} + 3x\text{CuCl}_2 = 2x\text{Cu}_2\text{Cl}_2 + x\text{NiCl}_2 + x\text{S}$
- (1a) $\text{CuS} + \text{CuCl}_2 = \text{Cu}_2\text{Cl}_2 + \text{S}$
- (1b) $\text{NiS} + 2\text{CuCl}_2 = \text{Cu}_2\text{Cl}_2 + \text{NiCl}_2 + \text{S}$
- (2) $\text{Cu} + \text{Ni (copper-nickel alloy)} + 3\text{CuCl}_2 = 2\text{Cu}_2\text{Cl}_2 + \text{NiCl}_2$
- (3) $\text{Cu} + \text{CuCl}_2 = \text{Cu}_2\text{Cl}_2$
- (4) $\text{Ni} + 2\text{CuCl}_2 = \text{Cu}_2\text{Cl}_2 + \text{NiCl}_2$
- (5) $2\text{CuNi} + 6\text{Cl} = \text{Cu}_2\text{Cl}_2 + 2\text{NiCl}_2$
- (6) $\text{Ag}_2\text{S} + 2\text{CuCl}_2 = \text{Cu}_2\text{Cl}_2 + 2\text{AgCl} + \text{S}$
- (7) $\text{FeS} + 2\text{CuCl}_2 = \text{Cu}_2\text{Cl}_2 + \text{FeCl}_2 + \text{S}$
- (7a) $\text{CuO} + 2\text{HCl} = \text{CuCl}_2 + \text{H}_2\text{O}$
- (7b) $\text{NiO} + 2\text{HCl} = \text{NiCl}_2 + \text{H}_2\text{O}$

The above reactions which proceed during leaching take place in an acid, alkali or alkaline earth chloride solution, such as salt or calcium chloride. The purification reactions are the following:

- (8) $2\text{AgCl} + 2\text{Cu} = \text{Cu}_2\text{Cl}_2 + 2\text{Ag}$
- (9) $2\text{FeCl}_2 + \text{Cl}_2 = \text{Fe}_2\text{Cl}_6$
- (10) $\text{Fe}_2\text{Cl}_6 + 6\text{NaOH} \text{ or } 3\text{Ca(OH)}_2 = \text{Fe}_2(\text{OH})_6 + 6\text{NaCl} \text{ or } 3\text{CaCl}_2$

The reactions taking place during the electrolysis,

- (11) $\text{Cu}_2\text{Cl}_2, \text{NiCl}_2 + \text{current} = 2\text{Cu} + \text{Cl}_2 + \text{NiCl}_2$, with secondary action on the anode.
- (12) $\text{Cu}_2\text{Cl}_2 + \text{Cl}_2 = 2\text{CuCl}_2$
- (13) $\text{NiCl}_2 + \text{current} = \text{Ni} + \text{Cl}_2$

If the production of copper and nickel restricts itself to a refining proposition using soluble metal-bearing anodes we have

- (14) $\text{Cu}_2\text{Cl}_2, \text{NiCl}_2 + \text{current} + \text{CuNi anode} = 2\text{Cu} + \text{Cu}_2\text{Cl}_2, \text{NiCl}_2$
- (15) $\text{Cu}_2\text{Cl}_2, \text{NiCl}_2 + \text{current} + \text{Ni anode} = 2\text{Cu} + 2\text{NiCl}_2$
- (16) $\text{NiCl}_2 + \text{current} + \text{Ni anode} = \text{Ni} + \text{NiCl}_2$

In the Browne process we have the following reactions:

- (1) $2\text{CuNi} + 6\text{Cl} = \text{Cu}_2\text{Cl}_2 + 2\text{NiCl}_2$

Refining reaction, that is, electrolyzing with copper-nickel anodes,

- (2) $\text{Cu}_2\text{Cl}_2, \text{NiCl}_2 + \text{current} + \text{CuNi anode} = 2\text{Cu} + \text{Cu}_2\text{Cl}_2, \text{NiCl}_2$

Purification reactions,

- (3) $\text{Fe}_2\text{Cl}_6 + \text{NaOH} + \text{NiCl}_2 = \text{Fe}_2(\text{OH})_6 + 6\text{NaCl} + \text{NiCl}_2$

Nickel electrolysis using insoluble anodes,

- (4) $\text{NiCl}_2 + \text{current} = \text{Ni} + 2\text{Cl}$

In comparing Browne's reactions with those of Hoepfner a great similarity is noticeable. This is especially the case in reactions 13, of the Hoepfner process, and 4, of the Browne process. These two single reactions are identical. In fact, the only differences between the two processes are that Mr. Browne uses a more refined grade of raw material in the leaching process, a refining and separation of copper from cuprous chloride and nickel chloride solutions dependent upon soluble anodes, a slightly increased temperature at which electrolysis takes place, and the employment of concrete baths. Further Mr. Browne makes use of porous tile diaphragms in the nickel electrolysis, whereas Hoepfner uses nitrated cotton ducking.

The employment of concrete or cement tanks, together with porous tile diaphragms, presents nothing new in the art of electrometallurgy. Bodý having employed the same during

his electrochemical research work. The historical development of the Hoepfner process and the Browne process clearly proves that there are points of vital economic interest in the electrolytic production and separation of metals from chloride solutions.

It may be here mentioned that the success attained up to the present time in the commercial production of copper, nickel, zinc and chlorine from chloride solutions by the process theoretically worked out by Dr. Hoepfner should be mainly credited to the tireless efforts of Dr. George Wannschaff, the technical head of the Papenburg Actien Gesellschaft für Metallelectrolyse. In 1899 an attempt was made to establish a zinc works in Canada. The Brunner-Mond works in England were operating to advantage, and the zinc bleach plant at Krauschau was nearing completion. The zinc works at Furfurt in Germany were closed, owing to personal difficulties, and not the failure of the process.

The method employed at the Brunner-Mond works for the preparation of zinc chloride solution consists in a roasting of the ore, thereby converting the zinc contents to a state of oxide. The zinc oxide so obtained is treated under a pressure with a solution of calcium chloride and carbonic acid gas, yielding thereby zinc chloride according to the following equation:

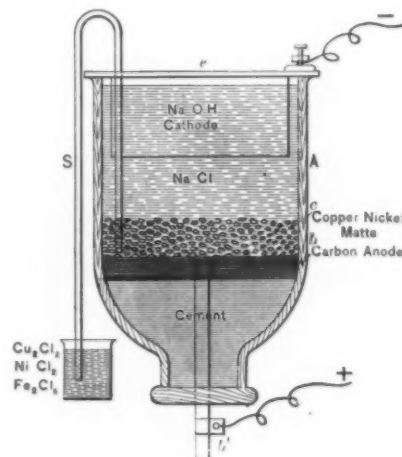


FIG. 4.—DEMONSTRATION AT HAMILTON.

The zinc chloride thus obtained after purification, removal of iron, manganese, etc., is subjected to electrolysis in the Hoepfner compartment bath yielding metal and chlorine gas. The metal produced is of exceptional quality, being practically chemically pure. Many samples have shown a zinc contents of 99.98 per cent.

In the works contemplated to be erected in Canada, Dr. Hoepfner wished to introduce a new method for the production of zinc chloride solutions, that is, in the leaching of zinc ores. It is a well-established fact that the success of any electrolytic process depends largely upon the economical and efficient production of the electrolyte used. The simpler the reactions, together with the successive operations, the more valuable the process becomes. The electrolysis in itself is nominal, and from a commercial point of view, a good paying proposition. The scheme proposed by Hoepfner for leaching zinc ores was as follows: The ores were to undergo a preliminary roasting, thereby yielding sulphurous acid and zinc oxide, the sulphurous acid evolved to be absorbed in water. With this aqueous solution of sulphurous acid an extraction of the zinc contents of the ore as sulphite of zinc was to be effected. The zinc sulphite was then to be precipitated as such through the removal of the excess of sulphurous acid.

The crystalline zinc sulphite thus obtained after commingling with iron oxide or roasted ore was to undergo a roasting, thus oxidizing it to zinc sulphate. This zinc sulphate was then to be calcined with salt, thereby producing zinc chloride and sodic sulphate. The roasted and converted product was finally to be extracted with water, the zinc chloride and sodic sulphate dissolved out, and the sodic sulphate separated through refrigeration. By this means it is possible to produce a solution of zinc chloride practically free from impurities. The following diagram shows the process in detail.

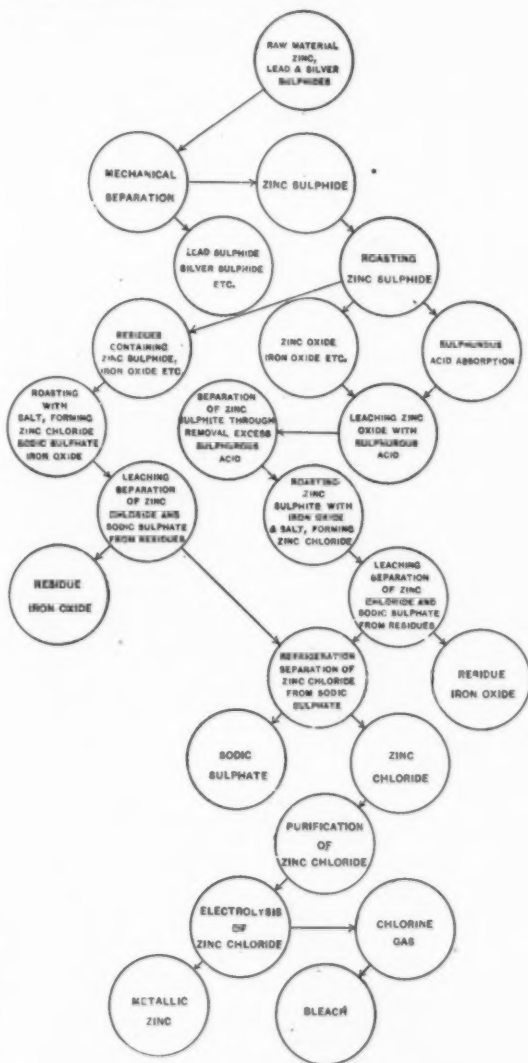


DIAGRAM OF HOEFNER PROCESS.

In 1900 the management of the Canadian Hoeftner Co., having, ever from the start, wished to produce copper and nickel rather than zinc, abandoned the zinc proposition. By previous contracts Dr. Hoeftner had transferred his copper and nickel rights with the exception of producing oxides and salts of these metals, to the Papenburg Actien Gesellschaft. Hoeftner therefore proposed plans, tending only towards the production of copper and nickel oxides and salts from Canadian nickel ores and mattes by his cuprous chloride process, chemically precipitating out the copper, nickel and cobalt as oxides from their respective chloride solutions, instead of electro-depositing the metal.

While Hoeftner wished to introduce a complicated method

for the production of a zinc chloride electrolyte, and the production of copper-nickel salts, instead of electrolytic metal, Mr. Frasch wished to substitute caseine diaphragms for nitrated cotton ducking, also to introduce a process for the production of sulphuric anhydride together with another process for the production of corn starch through refrigeration; under these conditions the legitimate production of metals from their chlorides was entirely lost sight of. The dissensions thus produced among the management threatened to attack the commercial practicability of the electrolysis of

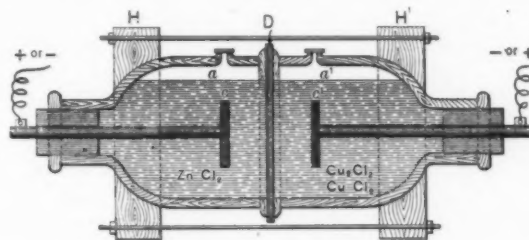


FIG. 5.—DEMONSTRATION AT HAMILTON.

chloride solutions, and the deposition of metals therefrom. In order to prevent this, and also to keep up the interest in this particular field of metallurgy, it was at this time shown and demonstrated that in a properly constructed compartment bath two different solutions could be electrolyzed at one and the same time, thereby producing some very interesting results. The production of alkali through the formation of metallic chlorides was also exhibited. The demonstrations made at this time were as follows. They referred to the electrolysis of a salt or brine solution in conjunction with a soluble disintegrating metal-bearing anode.

In Fig. 4 A is a vessel or receptacle containing a carbon bottom *b* provided with electrical connection *b*¹. Crushed copper-

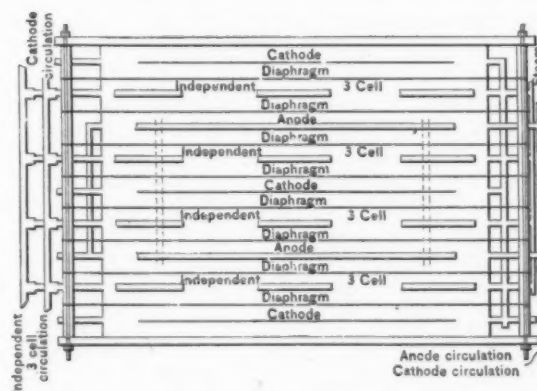


FIG. 6.—HOEFNER THREE-BELL BATH.

nickel-bearing material *c* placed upon the carbon bottom *b*. The vessel was filled with a solution of salt and a cathode *e* suspended therein; a siphon *S* was so arranged that the electrolyte could be removed from the bottom of the vessel. The reactions taking place were as follows:

- (1) $\text{NaCl} + \text{current} = \text{Na} + \text{Cl}$
Secondary reaction $\text{Na} + \text{H}_2\text{O} = \text{NaOH} + \text{H}$
- (2) $6\text{Cl} + 2\text{CuNi} = \text{Cu}_2\text{Cl}_2 + 2\text{NiCl}_2$
- (3) $(2\text{CuNi})\text{S} + 3\text{Cl}_2 = \text{Cu}_2\text{Cl}_2 + 2\text{NiCl}_2 + \text{S}$

This demonstration clearly proved the production of alkali with the formation of a copper-nickel chloride solution. In another demonstration (Fig. 5) the apparatus consisted of two tubulated bell jars, whose bottom edges were ground to fit

each other. The two jars, by means of head pieces H and H', with bolts through the same were tightly clamped together, after placing a semi-permeable diaphragm D between them. The jar A contained an electrode *c* of carbon with an electrolyte of zinc chloride. The jar A' contained an electrode *c'* of

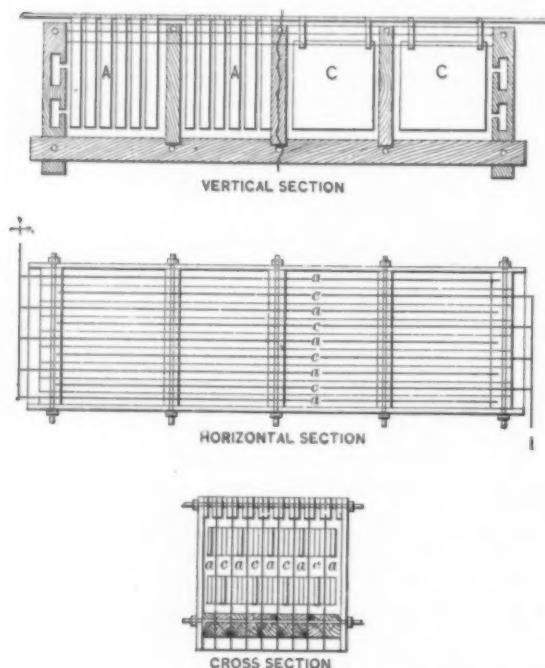


FIG. 7.—HOEPFNER COPPER BATH.

carbon, and an electrolyte of cupric chloride. Electrical connections were made as shown. These experiments showed that it was possible to either produce metallic zinc and chlorine gas or metallic copper and chlorine gas according to the direction of the applied current. Tests were also shown demonstrating

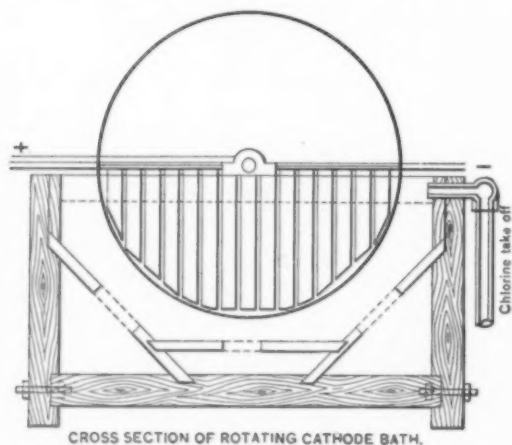


FIG. 8.—HOEPFNER NICKEL AND ZINC BATH.

the reversibility of primary or electrochemical current generators when used as energy absorbers.

The above possibilities having been communicated to Dr. Hoepfner by the writer during the latter part of 1899, he, in order to anticipate patents which might be applied for in this direction, viz., covering the electrolysis of a salt solution pro-

ducing thereby caustic soda together with metallic chlorides, also to circumvent the electrolysis of two separate and distinct electrolytes (compound electrolyte) contained in a unit bath, applied for patents upon a three-cell compartment bath (U. S. Patent filed Sept. 27th, 1899, granted March 12, 1903, serial No. 669, 926). Fig. 6 shows the bath, section 12 of patent specifications reads as follows: "A process which consists in placing a soluble anode of lead or copper in a solution of a salt capable of dissolving same, placing a suitable cathode in a second solution containing a metal of the alkalis, and an oxygen compound of a metal soluble in alkali metal solution, interposing a third solution between the two first mentioned, separating the solutions by suitable diaphragms, mentioned, separating the solutions by suitable diaphragms, passing the current, thereby bringing the anode metal into solution, depositing the cathode metal and forming an alkali hydroxide substantially as set forth."

The practical demonstration, as cited above, had the effect of making converts to the production of metals, especially copper and nickel, and alkali from chloride solutions. The management indorsed the same, and upon September 3, 1900, a demonstration was given by H. A. Frasch, announcing a new and improved discovery in the method of producing metals electrolytically.

The Frasch process, according to his claims, may be briefly summed up as follows. Claim 1 of patent 669,439 reads: An electrolytic bath having an anode extending over its bottom and consisting of a suitable electrical conductor and a body of dis-

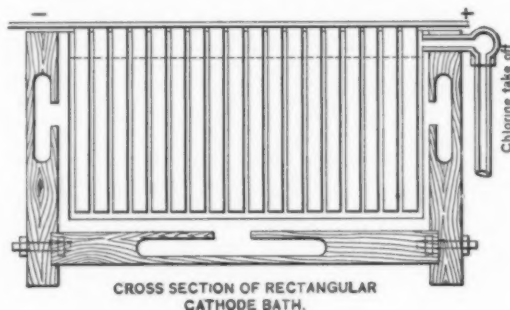


FIG. 9.—HOEPFNER NICKEL AND ZINC BATH.

integrated material containing the metal or metals to be extracted, a superposed layer of sand in immediate contact with the disintegrated material and suitable cathodes. Claim 4 of 669,440 reads: The method of recovering copper and nickel from matte or ore by electrolysis, which consists in disintegrating or pulverizing metal-bearing matte or ore so as to render it free permeable by an electrolyte capable of combining with the metal or metals to be extracted, distributing such mass over the bottom of vessel in which electrolysis is conducted and in connection with electric conductors to constitute an anode, covering said anode with a granular permeable electrically neutral substance, suspending in the electrolyte a number of cathode plates by and upon which the metal is collected and passing an electric current between the anodes and cathodes.

Claim 1 of 669,441 reads: The process of producing alkali and extracting metals from ores and metal-bearing mineral substances, consisting in electrolyzing a solution of salt of alkali in presence of an anode composed of disintegrated ore or metal-bearing mineral substance, containing the metal to be extracted and a suitable cathode, conducting a supply of a solution of a salt of an alkali, both to the anode and cathode, and displacing the metallic solution obtained at the anode and the solution of caustic alkali produced at the cathode.

Patent 720,235, granted February 10, 1903, is for the method of separating by electrolysis metals from their ores, which

consists in providing an electrolytic bath with a soluble anode composed of comminuted ore bearing the metals to be obtained, circulating successively through a series of such anodes an electrolyte capable of dissolving the metals contained therein and simultaneously circulating the electrolyte obtained from the whole series of anodes past the cathodes of one or more baths, and thereupon depositing the least positive metal, keeping the other metals in solution. Section 7 refers to the method of recovering nickel from nickel-bearing substances consisting in providing a series of electrolytic baths with

some time, alkali was produced at the cathode, while a solution of copper-nickel chloride was formed at the anodes. This virtually covered the whole of the Frasch demonstration. From the foregoing one could readily infer that a great similarity exists between the Frasch process and the demonstrations which were shown earlier in the season at Hamilton, Canada, for the main purpose of preserving the integrity of a process which consists in the production of metals through the use of their chloride solutions.

The *Eng. & Min. Journal* of September 8, 1900, contains

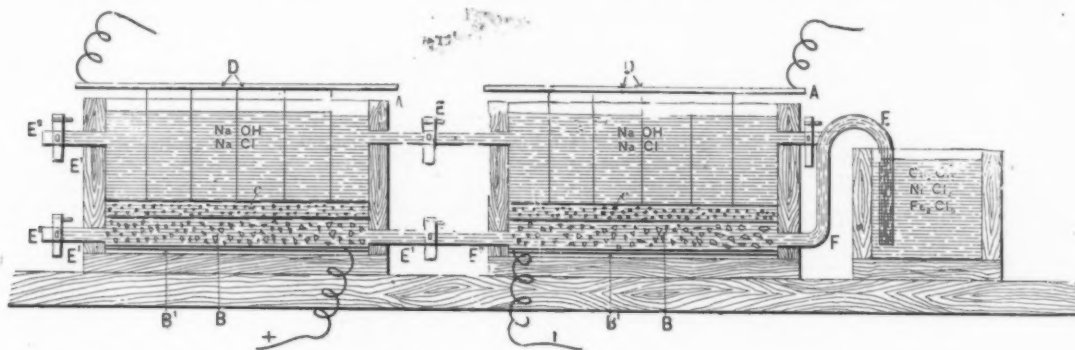


FIG. 11.—FRASCH PROCESS.

anodes composed of the comminuted nickel-bearing substances to be treated, electrolyzing the salt of an alkali in the first section of the series of baths, electrodepositing the copper from the electrolyte thereby obtained in the next section of the series of baths, removing by suitable means the iron contained in the electrolyte derived from the whole series of baths, and constantly producing fresh nickel-bearing electrolyte from the anodes of the whole series of baths.

The Frasch process, as shown and demonstrated at Hamilton, Ont., Canada, in September, 1900, may be described as follows. In Fig. 11 A is a vessel which contains a carbon anode B', composed of lengths of carbon rods placed at the bottom with suitable electrical connections. A layer of crushed copper-nickel matte B is placed over the same, the whole is covered

an account of the Frasch process, as given by Dr. Jos. Struthers. It was claimed at that time (see this article) that the entire cost of the process would be fully met by the value of the caustic soda and other by-products produced. It was even claimed that the caustic soda could be produced at less cost than by either the Castner-Kellner or the Rhodin process. The developments at Hamilton seemed to indicate that there was something radically wrong, either in the attempt to operate chloride solutions, or in the management, for it did not take long until the Frasch process arrived at a termination. At a special meeting of the board of directors of The Nickel Copper Co., of Ontario, Ltd., called two days after the Frasch demonstration, the fate which has befallen his attempt in electrometallurgy, although the same received the support of many eminent metallurgists, was predicted by the writer, and specific reasons given why the same would result in a failure. The failure of Mr. Frasch's attempt does not in the least affect the commercial value of the production of metals from their respective chloride solutions, provided the same be properly and intelligently handled from a technical standpoint. Owing to the death of the late Dr. Hoepfner, which occurred in November, 1900, the legal proceedings which he instituted against the management have, up to date, not been brought to trial. Since June 1, 1903, the Gesellschaft für Metallelektrolyse mit Beschränkter Haftung in Siegen, Germany, have, through purchase and otherwise, acquired all of the patents and rights of the late Dr. Hoepfner, and it is to be hoped that the recovery of metals from chloride solutions either through direct production or refining, will shortly be placed in that position in the metallurgical arts to which it is entitled.

THE SODIUM INDUSTRY IN FRANCE.

By P. LETHEULE.

For the extraction of alkali metals and alkaline earth metals there exist, as is well known, numerous patents. The processes best known in France, are the electrothermic processes of Mr. H. Becker and Mr. A. H. Cowles for extracting sodium, and the electrolytic process of Becker, which is used for the same purpose in several electrochemical plants, some of which will soon receive important extensions.

ELECTROLYTIC PROCESS OF H. BECKER.

The electrolyzer of Mr. H. BECKER consists of an iron tank

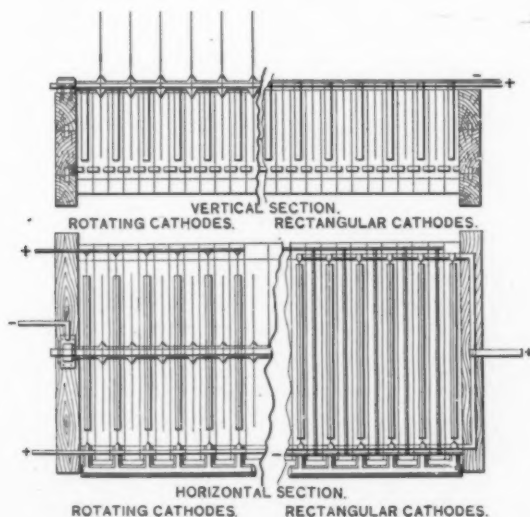


FIG. 10.—HOEPFNER NICKEL AND ZINC BATH

with a layer of sand C. The vessel is filled with a solution of sodium chloride, and suitable cathodes D are suspended in the electrolyte. After allowing the electric current to act for

A, to the bottom of which is attached a large tube *a* closed at its end by a cylinder of insulating material *a'* of porcelain or refractory earth. Through the hole in the center of this cylinder the rod *b* passes, at the end of which is fastened the cathode B. The tube *a* is surrounded by a cooling device *h*. The purpose of cooling the tube *a* is to render the electrolyte which is contained therein solid, so as to prevent any leakage between this tube and the plug *a'*.

The cathode B has a conical surface in order to enable the small particles of metal which are being formed at the cathode to rise perpendicularly upwards to the surface of the bath. The cathode may have, of course, any other form, suitable for this purpose.

The anode C is of annular form and surrounds the cathode entirely. It may consist of one or several pieces, and is made of iron or ferro-nickel. This anode is suspended in the bath by means of one or several bars *c* which serve as conductors, and which are fixed at its outer surface. The anode never rests on the bottom of the bath, and should not be higher than the cathode.

In the upper part of the apparatus a metallic piece of conical form is provided, which is insulated from the apparatus and serves for collecting the particles of metal which rise to the surface of the electrolyte. The form of this collector D is shown in the illustration. In its central part there is a tube *e* of sufficiently large diameter and of thick walls. This tube *e* is closed at the top by a hinged lid which serves as valve. Attached to this tube is the exit tube *f* which is slightly inclined. At the point where it passes through the wall of the apparatus it is insulated by means of a small tube or ring of porcelain *f'*.

The diameter of the collector D is somewhat larger than that of the cathode B and smaller than the diameter of the annular anode C. In this way the particles of metal which are deposited on the cathode are all collected by the collector D, while the gases developed at the anode can escape at the side of it. The border *d* of the collector is above the level of the electrolyte, so that the conical surface of the collector D is at its upper surface in contact with air. The purpose is to prevent an abnormal elevation of the temperature.

The collector D is connected in parallel with the negative conductor *g* by means of a suitable resistance, so that only a very small current can pass through this circuit. We have, therefore, in effect only one anode C, but two cathodes B and D, but the arrangement is so that considerably more current passes from the anode C to the cathode B than to the cathode D. The metal which is deposited at the main cathode B rises upwards so quickly that it is not redissolved in the electrolyte, and as soon as it touches the lower surface of the auxiliary cathode D, it becomes electrically a part of the latter, so that it is not attacked again by the bath.

The electrolyte is maintained in a fused condition by the heat developed by the passage of the current. Under these circumstances it is possible to have only the central part of the mass in a fused state, so that the durability of the apparatus is assured.

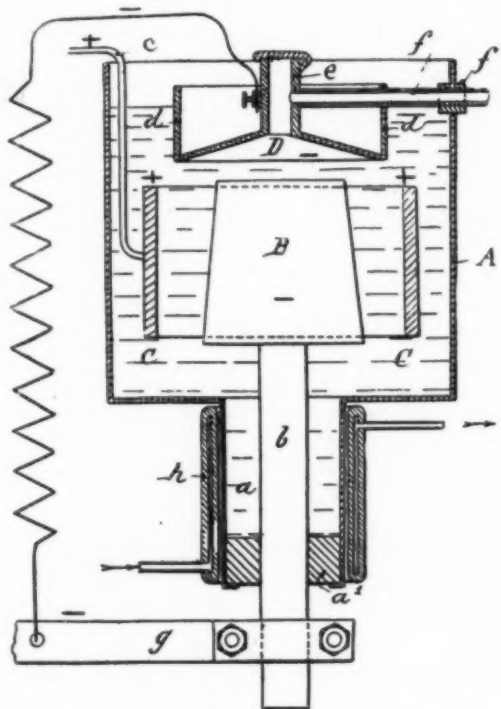
As electrolyte a mixture of caustic soda and carbonate of sodium is used. The metal which flows out of the exit tube is collected in a nearby hermetically closed ingot mould.

The first electrolytic apparatus of H. Becker was installed in 1899 by l'Affinerie Electro-Métallurgique de Bellegarde sur Valserine. At present the Becker sodium process is used by the Usines de Riqueroux (*Papeterie et Electrochimie*) (Isère), where apparatus for 1,250 amperes are installed. But since it has been decided to install machines for several thousand amperes, and since the results so far obtained are excellent, it has now been resolved to carry out at Riqueroux the manufacture of sodium on a large scale.

According to the inventor the expenses of the installation of a plant for making 500 kg. of sodium per day are as follows:

Ground, 1,200 square meters.....	\$360
Construction of plant and storeroom, 300 square meters	5,000
Office building, one story, 100 square meters.....	3,000
Apparatus (14 electrolyzers of 5,000 amperes, conductors, etc.)	3,400
Smaller apparatus (ingot moulds, etc.)	500
Repair shop	600
Packing and shipping room	400
Laboratory	340
Total	\$13,600

In order to obtain the cost of manufacture we will assume that the plant is situated near a hydro-electric power plant,



BECKER ELECTROLYTIC APPARATUS

from which it receives the current. The annual expenses are estimated as follows:

400 tons of electrolyte (mixture of caustic soda and carbonate of sodium at \$4.40 per ton)	\$17,600
500 hp. at \$10.00	5,000
18 workingmen on the electrolyzing vats, 6 workingmen for the foundry and ingot moulds, 3 for shipping and 3 extra men; together, 30 men (day of 8 hours, \$1.00 per day)	10,800
One superintendent	2,400
One foreman	720
One bookkeeper	600
Maintenance of apparatus, electrodes, etc.	3,600
Five per cent interest on capital	680
Sinking Fund, 10 per cent.....	1,360
Total	\$42,760

For the production of 180,000 kg. (360 working days) the cost of the kilogram of metal becomes 0.236 cents. This cost does not comprise the wooden and iron boxes for shipping.

ELECTROTHERMIC PROCESS OF H. BECKER FOR THE MANUFACTURE OF CHROMIUM, MANGANESE AND SODIUM.

The electrothermic process of H. Becker is based on the reduction, by means of carbon, not only of the alkaline oxides or

carbonates, but also of the alkali chromates, tungstates, aluminates, etc. The reduction, by means of carbon, of the alkaline oxides and carbonates has been well known for a long time, but nobody had used the electrical furnace on an industrial scale for this purpose. It had been tried without success for the production of sodium carbide by a method analogous to that of Willson for the preparation of calcium carbide.

By heating in the electric furnace sodium hydrate or sodium carbonate with carbon, no sodium carbide is produced, or, if it should be formed, it is at once again decomposed. In fact what escapes from the furnace are vapors of sodium, carbon oxide, etc., and if an excess of carbon is used it only remains in the furnace as graphite. If a mixture of sodium hydroxide and carbon is heated in a retort furnace like those of Castner and Netto, used a dozen years ago, there is formed sodium, carbonate of sodium, and hydrogen according to the formula $3\text{NaOH} + \text{C} = \text{Na}_2\text{CO}_3 + 3\text{H} + \text{Na}$.

By the Netto process 6 kg. of caustic soda and 1.5 kg. of carbon produced 1 kg. of sodium and 9 kg. containing 60 per cent. of carbonate of soda. The output of the Castner process was still smaller, since to produce 1 kg. of sodium 8.3 kg. of caustic soda were required. In these two processes 8 to 12 kg. of fuel were required per kg. of sodium produced and the wear and tear of the retorts was 1 to 1.2 kg. of cast iron per kilogram of sodium produced.

In the still older process of Sainte-Claire Deville no caustic soda was used, but sodium carbonate. Unfortunately, it was necessary to use retorts of very small diameter to obtain a sufficiently high temperature. The efficiency was low and the expense for fuel was rather considerable. At an elevated temperature, sodium carbonate decomposes according to the formula $\text{Na}_2\text{CO}_3 + \text{C} = \text{Na}_2 + \text{CO}_2 + \text{CO}$.

In the electric furnace a higher temperature is obtained than is necessary, and it is not necessary to use these retorts, which is a great advantage. However, while there is a saving of retorts there is an expense for electrodes. Moreover, electric distillation furnaces for metals as liable to oxidation as sodium are pretty difficult to design, and it is not possible to give them large dimensions, so that the expense for manual labor is high.

In fact, the furnace process of the reduction of caustic soda, and of sodium carbonate presents no special interest, in view of the improvements which have recently been made in the electrolytic process by Becker, Darling, Hulin, etc. The situation is, however, different concerning the furnace reduction, by means of carbon, of the chromates, aluminates, tungstates of sodium, etc.

By heating in an electric distillation furnace, sodium chromate and carbon, one obtains sodium, which distills off and is collected in a condenser, and chromium of excellent quality, which is tapped from the furnace. By treating mixtures of salts, or mixtures of salts and oxides, it is possible to produce alloys. By heating, for instance, sodium chromate and sodium aluminate with a sufficient quantity of reducing agent, an alloy of chromium and aluminium is obtained which remains in the furnace, while sodium distills off. Of course, the oxides or salts which are to be reduced must undergo a preliminary dehydration by calcination.

The most interesting claim of Becker's French patent, 288,274 of April 27, 1899, refers to the reduction in an electric (arc or resistance) distillation furnace, of the chromates, manganates, tungstates, ferrates or other salts, of which the acid radicle is metallic and one of the metals of which is more volatile than the other, by means of carbon or metallic carbides for the purpose of producing simultaneously the metals of the salt, the separation being effected by the sublimation of the one of them. This reduction can be made with or without addition of a material which does not participate in the chemical process, but serves only for making the mass more or less fusible according to the conditions of the case.

The process of H. Becker has been tried with success, and

will soon be applied on an industrial scale to the manufacture of chromium, manganese, etc., and of sodium.

To conclude this short note on the processes of Becker, we may notice the recent application of sodium to the refining of iron. Sodium is already used for this purpose in several plants, but it is unfortunately impossible to get at the exact results which have been obtained there. It is certain that sodium can replace aluminium, and it seems possible that it may be again replaced by calcium. The latter metal is experimented with at some extent at present, and Mr. Becker has invented an economical process of manufacture which we hope to describe in the near future.

The principal objection to the use of sodium in metallurgy is that it is, although not dangerous, yet difficult to handle. According to H. Becker, sodium can be used successfully, not only in iron foundries, but for refining copper, zinc, nickel and certain alloys. To make its use easy he proposes to deliver it to the metallurgical plants in boxes made of the same metal, which is to be refined. For iron foundries, for instance, sodium may be delivered in sheet-iron boxes, which may be placed in the tapping hole. The sodium manufacturer, instead of cooling the sodium in ingot moulds, would cool it directly in these boxes.

The quantities of sodium which we believe we can recommend for use in metallurgy are as follows:

For steel, 0.01 to 0.025 per cent; for copper, 0.2 to 0.25 per cent; for brass, 0.2 to 0.25 per cent; for zinc, 0.1 to 0.15 per cent; for nickel, 0.05 to 0.06 per cent.

For copper and nickel one uses at present, in several plants magnesium, the price of which is several times higher than that of sodium, and in certain foreign plants zinc of a bad quality is refined with phosphorous and magnesium.

THE ROLE OF FORMATION HEATS OF ALLOYS IN ELECTROLYSIS.

By JOSEPH W. RICHARDS.

The abstract in the November number of *ELECTROCHEMICAL INDUSTRY*, page 547, of the article in the *Journal de Chimie Physique*, by Lonquinine and Schukareff concerning the heat of formation of copper-aluminium alloys, gives rise to the query as to how these values should be utilized by the electrochemist in his calculations of the work done by the current in forming or decomposing alloys.

The values given by Lonquinine and Schukareff are the gram calories evolved in the formation of a gram of each alloy. The first five are exothermic, the last endothermic. (In the abstract, the minus sign was omitted from the last value, — 57.2, and the abstractor was wrong in his presumption that the values given were the kilogram calories per gram molecular weight of alloy formed.)

The correct data, and their derived values, which serve as the starting point for any electrochemical calculations, are as follows:

Formula.	Heats of Formation.			
	Per Cent of Al.	Molecular Weights.	Per Gram of Alloy.	Per Molecular Weight in Grams.
Cu_2Al	12.5	217.9	123.5	26,910
Cu_3Al	17.6	154.3	137.9	21,278
Cu_4Al	22.1	245.0	71.0	17,395
Cu_5Al	29.9	90.7	20.8	1,887
Cu_6Al	39.0	208.5	48.9	10,196
Cu_7Al	46.0	117.8	— 57.2	— 6,738

None of these quantities, however, are directly applicable to electrochemical calculations, because they do not concern the chemical equivalent weights (deposited by 96,540 coulombs) of the aluminium, or copper, or alloy concerned. The copper may be in or pass into the electrolyte as a monad or dyad, the aluminium as a triad. Therefore, the formula of each alloy may represent, electrolytically, the following number of equivalents of the respective elements:

Formula	Cu ₂ ⁺	Cu ₂ ⁺⁺	Al ₂ ⁺⁺⁺	Cu ₂ +Al ₂ ⁺⁺⁺	Cu ₂ +Al ₂ ⁺⁺
Cu ₂ Al	6	3	3	9	6
Cu ₂ Al	4	2	3	7	5
Cu ₂ Al ₂	6	3	6	12	9
Cu Al	2	1	3	5	4
Cu ₂ Al ₂	4	2	9	13	11
Cu Al ₂	2	1	6	8	7

It follows from this, that the calories concerned in the solution or deposition of one of the above alloys, reckoned per 96,540 coulombs of current flowing, or one chemical equivalent concerned, varies, according to which ingredient of the alloy is the one dissolved or deposited, or whether the alloy, as a whole, is dissolved or deposited. The quantity required may be obtained by dividing the molecular heats of formation by the chemical equivalents concerned, as classified in the preceding table. We thus obtain the following table of heats *absorbed*, let us say, per 96,540 coulombs passing, under each of the five possible cases already classified, when the alloys are corroded:

I. When Cu only is dissolved, going into solution as cuprous salt.

II. When Cu only is dissolved, going into solution as cupric salt.

III. When Al only is dissolved.

IV. When the whole alloy is dissolved, the Cu dissolving as cuprous salt.

V. When the whole alloy is dissolved, the Cu dissolving as cupric salt.

Alloy attacked.	I.	II.	III.	IV.	V.
Cu ₂ Al	4,485	8,970	8,970	2,990	4,485
Cu ₂ Al	5,320	10,640	7,093	3,040	4,258
Cu ₂ Al ₂	2,900	5,800	2,900	1,450	1,835
Cu Al	943	1,887	629	377	472
Cu ₂ Al ₂	2,549	5,098	1,133	784	927
Cu Al ₂	3,369	6,738	1,123	842	963

It will be noted that the heat absorbed in the decomposition of the last alloy is negative, i. e., heat is evolved in its decomposition. The above values are heats absorbed in the corrosion and decomposition of the alloys. For formation of the alloys, heat will be evolved, according to the values of the above table, according to the ingredient which is deposited from the electrolyte.

All these heats, as given above, are directly convertible into voltage generated or absorbed, by dividing by the thermochemical equivalent of one volt, viz. 23,040 calories.

The principles involved in the above calculations are directly applicable to all cases of formation or decomposition, electrolytically, of alloys in general, including amalgams. The principle is well known where only one ingredient is deposited or dissolved, as in the formation and decomposition of sodium amalgam, but the above calculations cover the case also of *both* ingredients being simultaneously deposited or dissolved.

Metallurgical Laboratory,
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KJELLIN'S ELECTRIC FURNACE AT GYSINGE, SWEDEN, FOR THE MANUFACTURE OF STEEL.

By FRANK C. PERKINS.

The accompanying illustration, Fig. 1, shows the top of the Kjellin electric furnace at Gysinge, in Sweden, about to be charged, while Fig. 2 shows the side of the furnace with liquid steel issuing from the furnace, and drawing, Fig. 3, shows the details of construction of the furnace.

It is held by F. A. Kjellin that in resistance furnaces with electrodes the steel very easily takes up the impurities from the electrodes consumed, and the cost of the electrodes increases the expense of the output, while the carbonic oxide resulting from the oxidation of the electrodes has a very bad influence by preventing the steel from giving off the carbonic oxide dissolved in it.

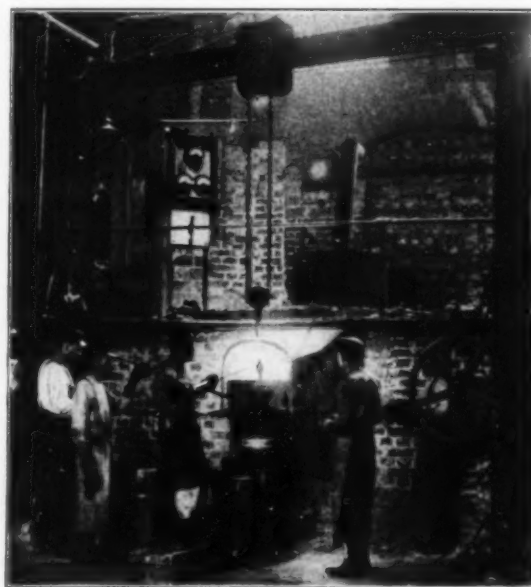
The steel can be more uniformly heated by passing an electric current of many amperes through the steel and using the heat evolved by the resistance of the steel for smelting. Kjellin states that as the resistance of the metals when molten is comparatively low, the currents used must be so great that the copper cables have a section at least as great



KJELLIN ELECTRIC STEEL FURNACE.

as that of the steel in the furnace. The Swedish inventor, De Laval, tried to avoid these difficulties by using molten slag instead of steel as resistance in his furnace, but it is thought the result was not satisfactory.

As the carbon electrodes in furnaces of this kind have high resistance, great losses of tension and power result. Water-



KJELLIN ELECTRIC STEEL FURNACE.

cooled iron electrodes might be used, possibly, but then the magnetic properties of the iron cause new difficulties to arise. In order to get sufficient intensity of current, alternating currents must be used and then the magnetism causes the concentration of the current at the surface of the electrodes (skin effect) and the result is a great loss of power. On account of self-induction the capacity of the electric generator is also diminished.

In May, 1899, in Stockholm, Sweden, Mr. Kjellin proposed to Mr. Benedicks, general manager of the Gysinge Works, to eliminate these difficulties by constructing an electric furnace without electrodes. This was accepted, and the furnaces were built, as shown in Figs. 1 and 2, details of which are indicated in drawing, Fig. 3, which shows the principle of the furnace.

with the coil *d,d*, and the current when passing through the coil excites a varying magnetic flux in the core and this flux induces an alternating electric current in the contents of the furnace chamber.

The operation is, in fact, similar to a step down transformer having a large number of primary turns and a single secondary turn. The steel in the furnace forms only a single

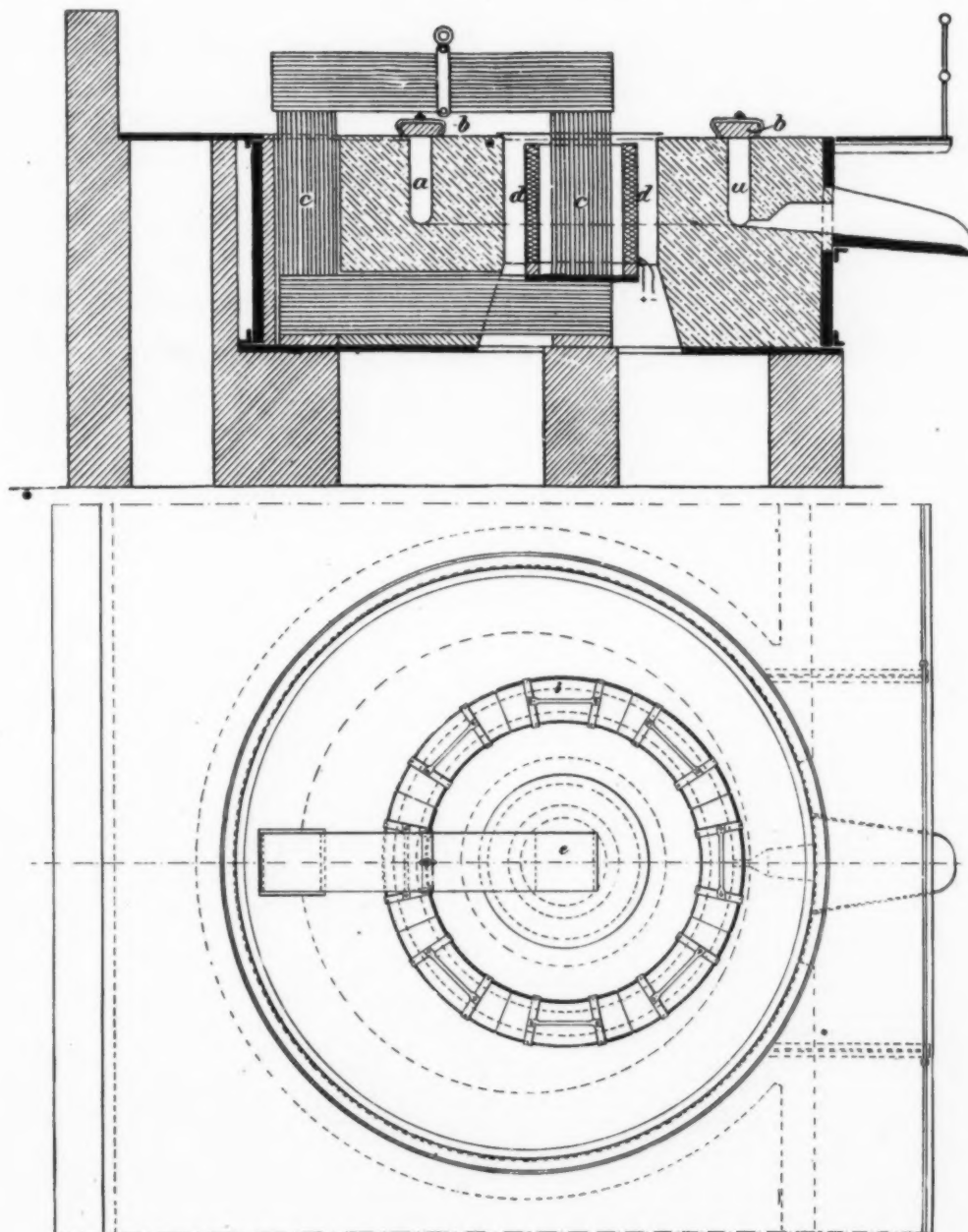


DIAGRAM OF KJELLIN FURNACE.

The groove *a,a*, forms the furnace chamber, the sides and bottom of which consists of refractory bricks, and covers *b,b*, are used to close the furnace. A quadrangular iron core *C*, formed of thin insulated sheets of soft iron, is in the center of the circle formed by the furnace chamber and this is enclosed by a coil *d,d*, of insulated copper wire. The core continues outside the furnace and forms with the furnace chamber the two links of a chain. An alternator is connected

turn round the core, and the current in the steel is then equal to about the primary current in amperes multiplied by the number of turns of wire in the primary coil. The voltage of the current in the steel is of course reduced in the same ratio as the number of amperes are increased. It will thus be seen that it is possible in this way to use an alternating current generator of high tension and yet no transformers are necessary nor copper cables of large sections. The costly

and uneconomical carbon electrodes are also avoided, and yet a heavy current is obtained in the furnace with a low voltage.

The first furnace was installed at Gysinge, Sweden, in February, 1900, and the first ingot was cast on the 18th of March, while it is stated that steel of an excellent quality was produced from the beginning. This solved the problem from a technical point of view but not from a commercial standpoint, for with an electric generator of 78 kilowatts capacity it took twenty-four hours to produce 270 kg. of steel. In November of the same year another furnace was constructed which was able to produce from 600 to 700 kgs. of steel in twenty-four hours with 58 kilowatts, the charges being 100 kg. every three or four hours. On account of the cooling surface of the walls being too great in comparison to the contents of the furnace the output was not satisfactory and the cost of repairs was too high. In August, 1901, a fire destroyed the sulphite pulp mill at Gysinge, Mr. Kjellin states, and then, instead of rebuilding the same, the water power was utilized for steel making by electric smelting and a new plant was constructed for this purpose. This electric steel furnace plant was started in 1902, and since May of that year has worked extremely well. The furnace shown in the illustrations contains 1,800 kg. of steel, 1,000 kg. being drawn off at a time, the remainder being left to keep the current flowing. It produces 4,100 kg. of steel ingots in twenty-four hours when charged with cold materials with 165 kilowatts or 225 electrical hp.

A single phase alternating current generator is employed which generates a current of 3,000 volts pressure. This single phase alternating current is transformed by means of the primary coil and iron core of the furnace into a current of about 30,000 amperes in the steel that forms the secondary circuit.

At Gysinge there is produced only first-class steel from excellent Dannemore pig iron and wrought iron. The method of operation is as follows: When the steel has been drawn off and about 800 kg. left to keep the current flowing, the furnace is charged with pig iron and bar ends as well as steel scrap in such proportions as the experience has proved will give the percentage of carbon wanted. The resulting steel always has less carbon than the material charged, as the pig iron is usually more or less rusty. When the charge has melted and overheated to a proper degree the metal is draw off by tapping in the same way as at the open hearth furnace by a hole in the wall of the furnace.

As will be noted by the illustrations and drawing, the upper part of the Kjellin electric steel furnace is on the same level as the working floor, and the charging is accomplished by simply taking off the covers and putting in the material. As the heat is produced in the steel itself the slag is not so hot as in other steel furnaces, and so the workmen do not suffer from the heat to the same degree.

It is stated that the steel produced is of an uncommonly dense and excellent quality, being homogeneous and unusually tough. It may be easily worked cold when annealed, and is not disposed to crack and warp at hardening as with other kinds of steel. Mr. Kjellin thinks the reason of this is that the steel contains less gaseous matter than other steel, as even small quantities of gases, especially hydrogen, are harmful. He has the following to say in reference to the avoidance of gases in the Kjellin furnace and as to the cost of production of steel ingots:

"By the electric furnace described above the steel has no opportunity of taking up such gases or other impurities, and the quality is also better than that of crucible steel with the same analysis. To make special steels with nickel tungsten or chromium offers no difficulties and the alloys are quite homogeneous. The cost of production depends principally on the efficiency of the furnace and the price of the power.

"At the furnace now in use at Gysinge the losses have been

experimentally proved to be 87.5 kilowatt, so that the effective power absorbed by the steel is $165 - 87.5 = 77.5$ kilowatts, and as those produce 4,100 kg. of steel in twenty-four hours, one effective kilowatt produces about 53 kg. steel ingots in the same time. Every kilowatt more in the furnace when the size is not altered increases then the output with 53 kg., and we calculate, when we within a few months get a stronger waterwheel, to produce about 6,000 kg. of steel ingots with 200 kilowatts in twenty-four hours. As the absolute cost of labor and repair will be the same those costs for one ton of steel ingots will be about two-thirds of the cost now, and the price of power per ton will also be sensibly diminished.

"The cost of repair, that is, of renewing the lining of the furnace when it is worn out, is now at Gysinge \$60.

"From our experience with this furnace, we calculate that a furnace of 736 kilowatts or 1,000 electric hp. will produce 30,000 kg. of steel ingots in twenty-four hours when charged with cold materials. With hot materials the output is much greater. For instance, if 250 kg. of molten pig iron are charged for each ton of steel ingot produced, the output is increased from 30,000 to 36,000 kg. in twenty-four hours with 1,000 electric hp.

"The costs of labor and repairs for such a furnace will in my opinion be less than those of an open hearth furnace of the same size, so that, where power is cheap, there is a possibility of producing a steel competing with the dear crucible steel at a smelting cost not exceeding that of the open hearth furnace."

DR. HANS GOLDSCHMIDT'S LECTURE ON ALUMINOTHERMICS.

On November 13th, Dr. Hans Goldschmidt, of Essen, Germany, delivered a lecture before the Chemical Society of Columbia University, and a large number of invited guests, on the subject of his thermit process. The lecture hall of the Havemeyer building of Columbia University was crowded, and the perfect success of the experiments shown by Dr. Goldschmidt was highly appreciated by the audience.

Since we have published, in our last issue, an article by Dr. Goldschmidt on the subject of aluminothermics—which contains the most complete and up-to-date information on this subject—our account of his lecture may be brief.

The author defined thermit—in its wider sense—as a mixture of finely granulated aluminium and metallic oxide. The first important discovery in observing the properties of thermit was that, when ignited in one spot, the combustion continues throughout the whole mass without any supply of heat from the outside. The mass is placed in crucibles which are not in contact with any external source of heat, and the combustion when started embraces the whole mass in a very short time. This is the essence of aluminothermics.

The speaker remarked that fifty years ago it was already tried to supply the reducing properties of aluminium, but, without exception, the experimenters heated their compounds externally. The reaction was always so violent that they could operate with only small quantities. The result was with one exception only an aluminium alloy, not a pure metal. This one exception is the method of Messrs. Green and Wahl (Dr. Wahl is now the well-known secretary of the Franklin Institute, of Philadelphia) for producing pure manganese. But Prof. Green heated his crucible from the outside. While the present success of the applications of aluminothermics to various engineering purposes is based on the fact that the reaction will go on after it has once been started at one point.

Dr. Goldschmidt showed as first experiment the ignition of thermit and demonstrated in a second experiment the heat created by this reaction by burning a hole through a one-inch wrought iron plate. The crucible was tapped from the bottom so as to allow the pure iron, which has a temperature of about 3,000° C. (5,400° F.) to run out first. The hole burned through

the iron plate is perfectly smooth-edged; the heat is so concentrated that the plate is well cooled after the reaction.

As an example of the reduction of metallic oxides, the lecturer showed the reaction of nickel thermit. In the processes of producing pure metals free from carbon from their oxides, the slag which covers a regulus of pure metal is utilized as artificial emery on account of its great hardness. It is called corubin. It has also considerable refractory properties which have been utilized in various ways.

The lecturer then discussed at length the process of rail-welding and showed two experiments, one representing the welding together of ordinary running rails, and the other the method for welding the electric third rail. These experiments were made on a commercial scale, and after the lecture the apparatus was broken up and the rail weld was found to be perfect. The author then discussed the application of the thermit process to the repair of broken machinery, and remarked that within the last few months he has supplied thermit in regular ton orders to South Africa for repairing machinery of all kinds in the mining districts which had been damaged in in the late war. It should be of special interest to note that in many cases cast iron has been welded. The most effective work in the way of repairs by thermit has been done in connection with marine engineering, as was described at length in



Hans Goldschmidt

Dr. Goldschmidt's article in our last issue. The next experiment shown by Dr. Goldschmidt was the welding of thermit iron on a steel plate.

The last experiment made by Dr. Goldschmidt, and probably one of the most interesting and most successful ever shown in a lecture on a scientific or engineering subject was the welding together of two pipes. The process is known to our readers so that it is sufficient to say that in a few minutes the weld was completed. The screws were set, the thermit reaction was started, the mould was removed and the weld was found to be perfect. The heat had been concentrated entirely to the welding zone so that a few inches from the same the tubes were at ordinary temperature.

The conclusion of the lecture dealt with the application of thermit in the form of anti-piping thermit to foundry practice. This subject was discussed at greater length in Dr. Goldschmidt's articles in our last issue, but it may be mentioned that

in connection with ferro-titanium Dr. Goldschmidt called attention to the valuable studies and discoveries made by Mr. Rossi (who also contributed an article on his work to our last issue). Finally, Dr. Goldschmidt showed a number of lantern slide pictures, the greater part of which is known to our readers from the illustrations in our last issue.

We are pleased to illustrate this note by the portrait of Dr. Goldschmidt, and to add a brief sketch of his life. Hans Goldschmidt was born in Berlin, Germany, on January 18, 1861, where his father lived as the proprietor of a tin works, which he had founded in 1847. After having graduated from the "gymnasium" of Altenburg, Hans Goldschmidt studied chemistry, physics and natural science in general at the universities of Berlin, Leipzig, Heidelberg, Strassburg and at the Institute of Technology at Charlottenburg, his principal teachers being A. W. Hofmann, Landolt, Wiedemann, Bunsen, Kundt and Slaby. He received the degree of Ph. D. from the University of Heidelberg in 1886. Since 1887 he is partner of the firm of Theodor Goldschmidt. The works of the company were transferred in 1889 to Essen, since the real estate in Berlin was too expensive to allow necessary extensions of the factory. The works are now conducted by the two brothers, Dr. Karl Goldschmidt and Dr. Hans Goldschmidt, the output being mainly tin and tinsalts. Besides the electrolytic production of tin from tin scraps there is worked a process of producing tin from its ores. Another large product of the works is zinc chloride. In recent years Dr. Hans Goldschmidt has been mainly interested in the development of his ingenious thermit process.

SCHUCKERT SYSTEM FOR THE ELECTROLYSIS OF WATER.

In the November issue of this journal a rather full abstract was published of a recent article on the production of hydrogen and oxygen by electrolysis, mentioning in some detail apparatus designed by Garuti, Schmidt, and others. The system of Schuckert and Co., of Nürnberg, Germany, has been so successful commercially that a brief description of it may be of interest.

The apparatus, as now manufactured by the Siemens-Schuckert Co., of Berlin, is constructed, with the exception of the copper feed wires and the insulating material, entirely of iron. The cell proper of a unit designed to accommodate 600 amperes, consists of a cast-iron trough approximately twenty-six inches long, by eighteen wide and fourteen deep, requiring, when in operation, about 50 liters of electrolyte. In this trough are placed the iron electrodes. These are separated by strips of a

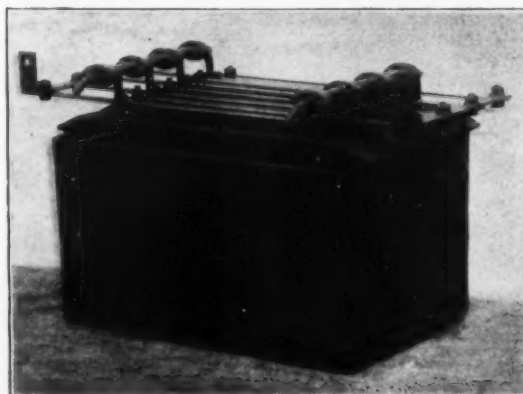


FIG. 1.—CELL FOR ELECTROLYSIS OF WATER.

good insulating material, extending from the top downward about three-fourths the depth of the cell. Between these separating plates and enclosing the electrodes are suspended iron bells, which collect and carry off the gas there generated.

The electrolyte is usually a 20 per cent water solution of

potassium hydrate, although a 15 per cent solution may be used. The concentration is maintained by supplying to the cells an amount of distilled water equal to that decomposed and carried away mechanically by the gas. The loss of potassium hydrate is inappreciable and may be entirely eliminated if the first wash water be used as feed water for the cells.

The units may be connected either in series or parallel with a drop of potential between electrodes of from two and one-half and three volts. The apparatus is operated most economically at a temperature of 70° C. When the cells are protected from radiation, as can be done, for example, by placing them on wooden boxes and packing them in one or two inches of sand, the heat effect of the passing current is sufficient.

The standard types of apparatus are designed to take from 100 to 1,000 amperes, and to furnish gas at a pressure equal to

THE ELECTRICAL CONDUCTIVITY OF COMMERCIAL COPPER.*

By LAWRENCE ADDICKS.

Electrical conductivity has come to be a universally accepted measure of the degree of purity of copper for two reasons: First, on account of the enormous quantities of copper used in electrical construction. Secondly, because the conductivity forms a very delicate test of the chemical purity of the metal. Furthermore, a conductivity test may be made upon a wire of suitable dimensions in about three minutes, while a chemical analysis of refined copper is a tedious and correspondingly expensive operation.

Matthiessen's standard (one meter-gramme of pure soft copper at 0° Centigrade = 0.14172 international ohms), has come into very general use, although it is some 3 per cent too low.

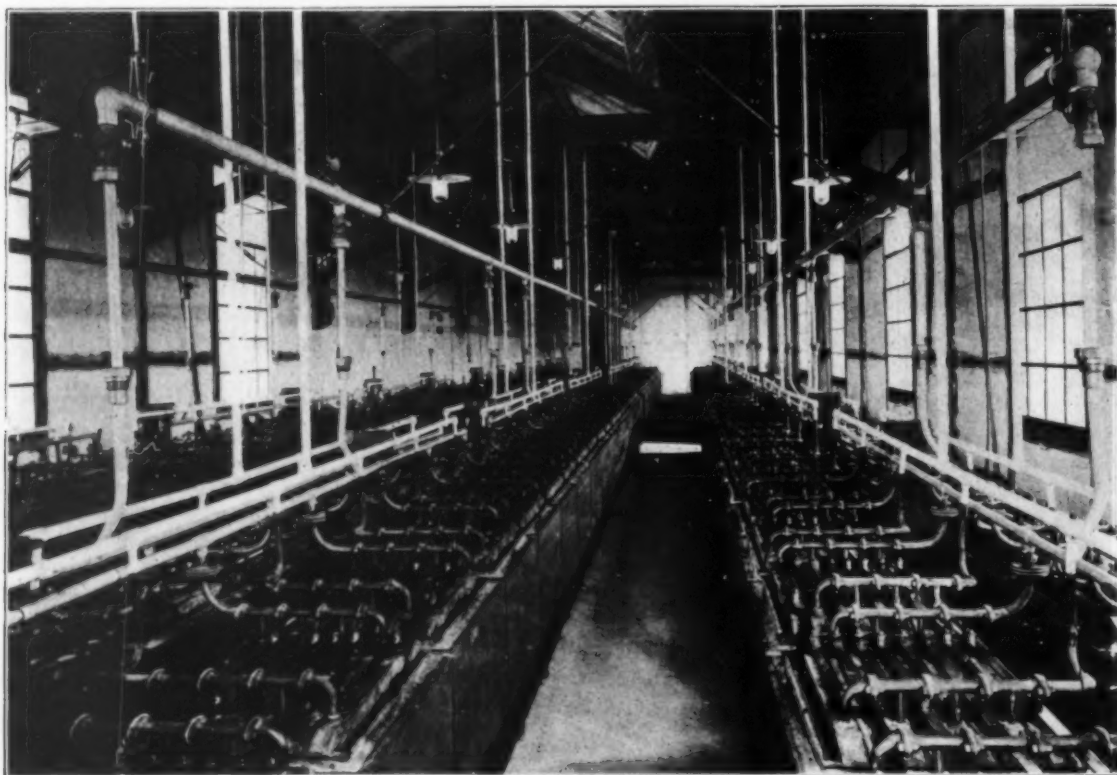


FIG. 2.—LARGE PLANT FOR THE ELECTROLYTIC GENERATION OF HYDROGEN AND OXYGEN.

a water column of 70 to 80 mm. For special purposes a cell delivering gas sustaining a water column of 760 mm. may be secured. Both the hydrogen and oxygen are obtained in a relatively pure condition, and the possibility of an explosive mixture is entirely eliminated. The production of normal types of apparatus is about 150 liters of hydrogen and 75 liters of oxygen per kw.-hour when measured over water at atmospheric pressure, and at 20° C.

The attention required for a plant of this kind consists simply in supplying the requisite amount of water to maintain the concentration constant. When in continuous operation the positive electrode, which is made up of a sheet iron plate two millimeters thick, should be replaced at the end of each year.

Attention has already been called to the economy of electrically preparing hydrogen and oxygen, and the many uses to which the gases are now put. The Siemens-Schuckert Co. has installed some very large plants in Europe, one of which is pictured in Fig. 2.

Laboratory of Industrial Chemistry,
Massachusetts Institute of Technology, Boston.

The fact that the quality of the copper on the market to-day often exceeds by as much as 1 per cent the purest laboratory copper of forty years ago, forms an interesting commentary on the excellence of modern methods.

Conductivity is affected by the physical state of a metal or alloy, as well as by its chemical constitution. Now, in order to obtain the sample of wire upon which a measurement is made, the copper under examination must be subjected to several mechanical processes, and these different variables must be taken into account. It is the purpose of this paper to point out their influence.

First, let us take up the influence of the chemical impurities commonly met with. These consist of oxygen in the form of suboxide of copper, arsenic, antimony, and, in some coppers, bismuth. Small quantities of some other elements may be met with, but those mentioned are the impurities to be looked for in low copper.

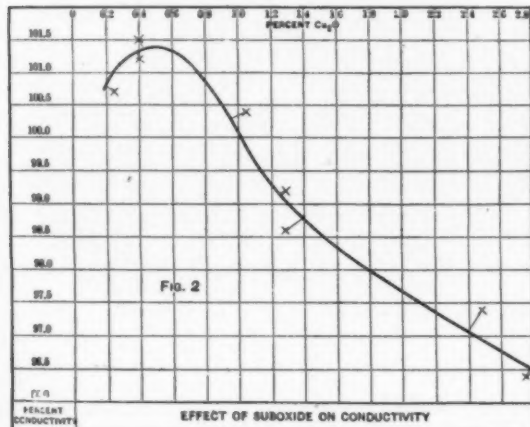
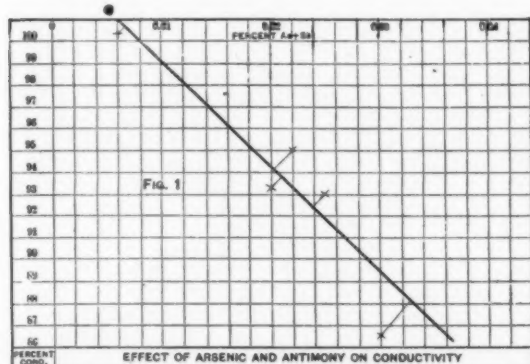
The relation between arsenic or antimony and conductivity

*A paper read before the American Institute of Electrical Engineers.

is shown in Fig. 1. As arsenic and antimony have a very similar influence, the data have been gathered as arsenic plus antimony, thereby greatly simplifying the work. The suboxide of copper is practically constant in all these determinations. The conductivity is stated for annealed samples of wire. It will be noticed that 1/100 per cent of arsenic or antimony lowers the conductivity about 5 per cent.

Fig. 2 shows the relation between suboxide and conductivity in annealed wire. The suboxide has been calculated from the oxygen, itself obtained by subtracting the per cent copper by analysis from 100. The quantity of other impurities present is so small that this is substantially correct. The crest of the curve shows copper "in pitch" or "set" or when sufficient oxygen is retained to keep the impurities as oxides, in which state they are supposed to be less harmful. The possible formation of a carbide or the absorption of hydrocarbon gases from "overpolling" in the refining furnace has also been suggested.

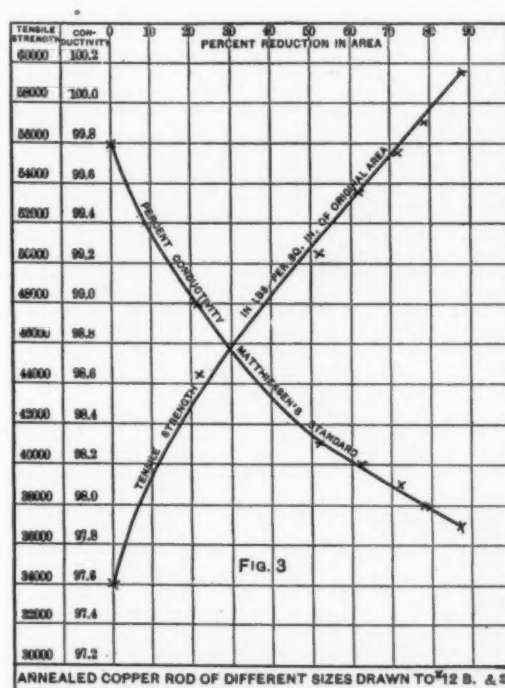
We come now to the physical characteristics and their influence upon the conductivity. We can cause considerable



changes in structure by mechanical operations, and, as would be expected, the conductivity is affected thereby, but by no means as seriously as by arsenic or antimony. The operation most commonly met with is that of wire-drawing—conductivity varies with hardness. In Fig. 3 conductivity and tensile strength are plotted against the percentage reduction in area of a wire rod after annealing, and in Fig. 4 conductivity is plotted directly with tensile strength. It will be seen that the tensile strength varies almost directly as the reduction in area, and that the conductivity drops about 1/10 per cent for every 1,300 pounds gain in tensile strength, a fact which must be taken into account when comparing different samples of hard-drawn wire. Fig. 4 also shows results obtained where a hard-drawn wire is given different degrees of annealing. This ratio, shown by the angle of inclination of the straight line to the axes, is independent, in so far as the writer's investigations have ex-

tended, of the actual conductivity of the annealed wire, which is, of course, dependent upon chemical purity.

Fig. 5 shows the effect of temperature in the annealing operation. A 12 B. & S. hard-drawn wire has been heated to various temperatures by being forced to carry currents from zero to a fusing current of about 220 amperes. The actual temperatures were not measured at the time the tests were made. Very roughly the temperature in degrees Fahrenheit will be about ten times the values shown for amperes. In the experiments quoted about 10 feet of wire was put in series with a water rheostat, and the whole shunted around 40 or 50 volts of a 4,000-ampere circuit. The current was adjusted by acidifying



the water in the rheostat, and was left on in each case until it reached a steady value—a matter of about a minute. The time during which the current was on, after this steady heat was reached, seemed to exert no other effect than to increase the shell of scale formed on the wire.

The question at once arises whether the lower conductivity due to overheating is caused by the absorption of oxygen in some way or to a crystalline change. The first idea that suggested itself was to anneal the wire in such a way that oxygen could not attack it. Handling white-hot wire of the length needed in an atmosphere of nitrogen proved somewhat troublesome, however, and was left as a last resort. Silver-plated wire was tried, but the plating would not stand the temperature. Finally the problem was attacked in two different ways. First, samples of burned wire were immersed in dilute nitric acid until the diameter was considerably reduced and then measured for conductivity. No appreciable difference was found, showing that any chemical change was at least uniform throughout the wire. Secondly, samples of burned wire were drawn to a smaller size, reannealed properly and then tested. The original wire, when properly annealed showed 100.4 per cent conductivity; when burned for the test, 99.1 per cent; and when drawn down and reannealed properly, 100.5 per cent. These results show the change to be of a physical, not chemical nature.

Figs. 6, 7 and 8 are micro-photographs of copper samples which have been polished and etched in 50 per cent aqua regia for about thirty seconds. The magnification and the size of rod

from which the samples have been cut are the same in each case. Fig. 6 shows good copper in "set," having a conductivity, when drawn and annealed, of 99.7 per cent. Pure metals when cast crystallize on cooling into irregular grains the size and distribution of which depend largely upon the size of casting and rate of cooling. When small quantities of impurities are present they form a matrix of what is probably an eutectic alloy of the metal and the impurities, in which the grains of pure metal are set. This is the case with the sample under discussion, where the total impurities amount to about one-tenth per cent. Each of these grains is made up of smaller crystals, the cleavage being in different directions in grains. Fig. 7 shows a

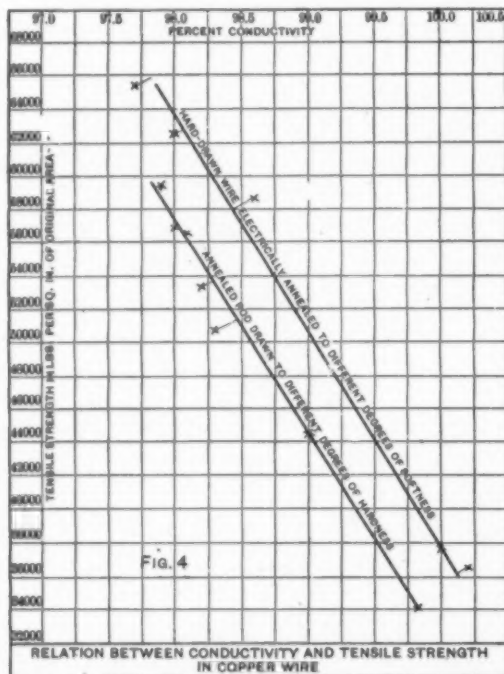


FIG. 4

copper low enough in pitch to give trouble at the drawbench. It is the lowest of the series of points on Fig. 2 and runs 96.4 per cent annealed. The change in structure is at once apparent and accounts for the brittleness developed.

When copper is rolled and drawn, this granular structure is broken down, a fine fibre resulting. Fig. 8 shows a sample of trolley wire which has been heated over a gas-blast to a bright heat. It shows a partial return to the crystalline state, the matter surface in places having the same appearance as a hard-drawn sample as far as fibre is concerned. This explains the lowering of conductivity by overheating. The writer has never made measurements of the conductivity of cast copper, but understands from work done at one of the wire mills, that it has been found to run about 3.5 per cent lower than the annealed wire. This is entirely in accord with the data shown above. Copper that has been remelted in the foundry may run but 30 or 40 per cent, due to the absorption of gases.

In cast copper we have a conductivity resulting from the combined conductivities of the pure copper grains and the impure matrix or cement. When this is rolled the structure is broken down and the complex shunt and series circuits rearranged to better advantage. When hard-drawn, the molecular freedom is restrained and more work has to be done in the necessary oscillation of an atom in passing a charge on to its neighbor. In annealing, the wire is brought to a temperature at which the cement is softened and all internal strain is equalized. In burning, crystalline growth is started and reverts the metal to the original condition.

President ARNOLD, in opening the discussion, remarked that Mr. Addicks' paper puts the matter in concrete shape for elec-

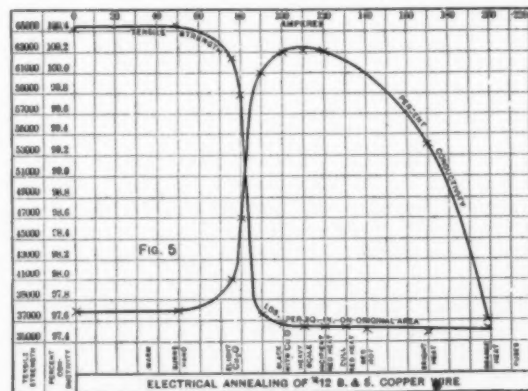


FIG. 5

trical engineers, and gives many of the things which some of them have been after when attempting to draw specifications for copper for electrical work. About the only specifications most electrical engineers have been able to draw is that the copper shall have 98 per cent conductivity of pure copper; what that is they had to leave entirely to the manufacturer.

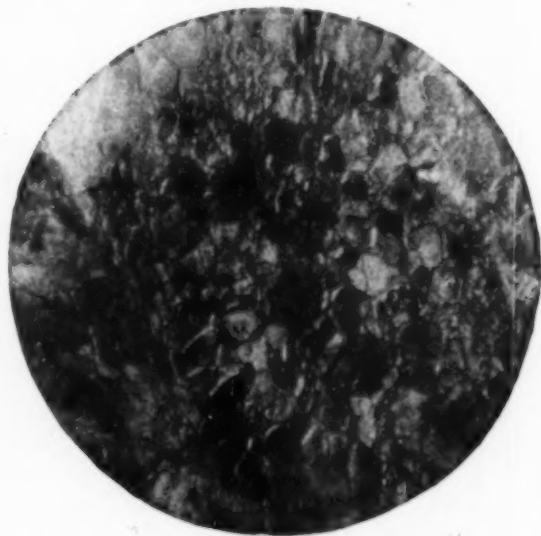


FIG. 6.—GOOD CAST COPPER. (LINEAR MAGNIFICATION 42).

Mr. F. J. NEWBURY, of Trenton, said at the Roebing Works, in the examination of copper, a method of testing is followed in which the conductivity of the copper expresses to us whether or not it is pure. The conductivity test is the most delicate and most easily applied to find, whether or not copper is in shape for proper working. He then discussed the drawing up of the specifications for copper strands. The speaker took the position that electrical engineers should draw their specification based upon the characteristics of the individual wires of the strand. If such wires are hard-drawn they have a strength of about 60,000 pounds per square inch, and should have a conductivity of 97 per cent, according to Matthiessen's standard. If one strands them, however, the resistance of the strand is not the same as the resistance of a copper wire of equal weight per foot; but the resistance is increased by about 3 per cent, apparently the amount taken up in the twist. In other words, the measured current seems to

follow the individual wires instead of passing freely along a line parallel to the axis of the strand. Similarly, the strength of the strand will be about 90 per cent of the individual wire composing it. Commercial copper of to-day comes very near to "100 per cent conductivity," according to the tables published by the American Institute of Electrical Engineers, and

for ordinary cases, is a very fair specification to make.

President ARNOLD saw difficulties in the desire of Mr. Newbury that electrical engineers should base the specifications on the properties of the individual risks. What the engineer wants to know is the net result, so that he can figure the conductivity of the strand complete over a given distance. He

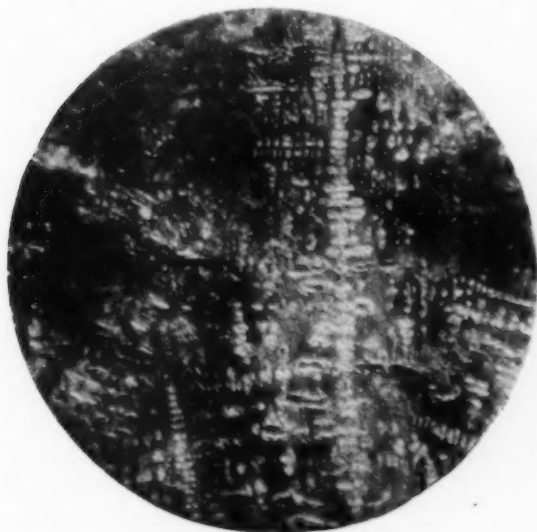


FIG. 7.—LOW CAST COPPER. (LINEAR MAGNIFICATION 42).

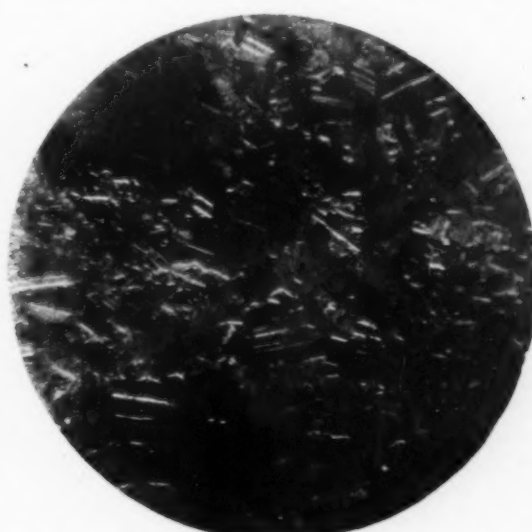


FIG. 8.—"BURNED" TROLLEY WIRE. (LINEAR MAGNIFICATION 42).

in strength it varies from 52,000 to about 65,000 pounds per square inch, depending upon the reduction in drawing. Sixty-eight thousand pounds is the maximum that can be obtained out of copper wire, and this is only accomplished by careful manipulation. Sixty thousand pounds to the square inch,

wants to know how much copper it will take to get a certain amount of energy over a given distance. He does not wish to be compelled to make the allowance as to what the difference in percentage in conductivity and strength is between straight wires and twisted strands.

SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

INDUSTRIAL ELECTROCHEMISTRY.

Ferro Metals and Their Manufacture in the Electric Furnace.—The *Iron Age* of November 12th contains an article by Rossi on the ferro metals and their electric manufacture. The author here deals with this subject from a different standpoint than in his article on the same subject, published in the November issue of *ELECTROCHEMICAL INDUSTRY*. He gives especially pretty full information on the properties and uses of the various ferros. In the first part of his article he discusses the reduction of metallic oxides by carbon and aluminium (see the article in our last issue), in the second part with the properties and uses of ferros. All the ferros are used in a general manner to impart to steel special qualities of hardness, toughness, ductility, strength, etc. The combined use of two or more of these ferro metals may also secure valuable properties for specific industrial applications.

Ferro-chrome, free from carbon (less than 1 per cent) or, in some cases, containing 3 to 8 per cent of carbon, is used more especially in the manufacture of shells and tempered products, tool steels and the like—in general, whenever properties of particular hardness are desired; though it secures them at some sacrifice in the toughness of the metal.

Ferro-tungsten is very much looked for in the manufacture of tool steel, 9 to 10 per cent tungsten being found in the finished steel, and lately as much as 25 per cent of tungsten is to be introduced into steel. The great weight of tungsten has

suggested its use for bullets. Tungsten steel possesses a very peculiar property. When forged red-hot and cooled slowly it presents an extraordinary degree of hardness, but if plunged red-hot in cold water, contrary to what happens with ordinary carbon steel, this hardness gives way to softness.

Ferro-molybdenum, used in steel in such quantities as to incorporate in the metal two or three per cent of molybdenum, imparts to it the peculiar property of "air-tempering" or "self-tempering." The author has seen 13-inch shells made of carpenter steel, planed with such molybdenum steel tools, running dry, and which cut ribbons of steel hot enough to be blue without the tool losing its temper. Under certain conditions of heat treatment and quenching it imparts to steel other valuable properties, hardness being a characteristic.

Ferro-vanadium appears to communicate to steel properties very much like those secured with nickel, and acts very much also like ferro-titanium. It is a new ferro, not very well known yet. It has been used chiefly experimentally. In the proportion of about 0.50 per cent in the steel, vanadium is said to increase the elastic limit wonderfully. It is very infusible, and in this respect stands next to ferro-titanium. One of the great drawbacks of its use is the scarcity of its ore, which must be highly concentrated, as it occurs sparingly in some rocks and commands a high price. The very lowest price the author has heard quoted for vanadic concentrates, is 50 cents per pound.

Ferro-silicon electrically smelted and containing some 25 to 30 per cent silicon and up to 50 per cent, has been much used of late in the manufacture of steel castings. It secures soundness and freedom from blow holes in the castings. It resists atmospheric influences remarkably well whenever the percentage of silicon reaches 25 per cent, or thereabouts, the effect increasing with the percentage of silicon.

Ferro-manganese containing 6 per cent manganese or thereabouts loses its magnetic properties, and at 13 to 14 per cent manganese it is practically non-magnetic. It possesses a great resistance to fracture by concussion. The maximum of strength appears to be secured in steel containing some 14 per cent of manganese. Such steels have been used for forgings, car wheels, and crushing and grinding machinery. It is toughened by water quenching, but does not temper in the sense in which the word is generally used.

Ferro-nickel, when used for armor plates, boiler plates and structural steel, has stood the tests of a prolonged practice. Some 3 to 5 per cent nickel is generally admitted to be necessary in the finished steel to secure the proper results. As much as 20 to 22 per cent nickel has been proposed for boiler plates. A 30 per cent nickel steel is well adapted for service in salt water, on account of its resistance to corrosive action. Its recognized action upon steel is to secure a high elastic limit and strength, combined with toughness.

The author finally discusses at great length the properties and uses of ferro titanium, and, besides the information given

that the tanks are heated electrically. The vertical scale at the left hand gives the power in watts, for the small experimental tank. For larger commercial tanks the power must be correspondingly larger, and the vertical scale at the right hand gives the power in kilowatts, required for commercial tanks of the size used by the Baltimore Copper Co. ($9 \times 2 \times \frac{1}{2}$ feet). From this the figures for other sizes of tanks may be calculated.

It will be seen that at 50°C the uncovered tank needs 42 per cent more power than the covered tank, and 75 per cent more power at 70°C .

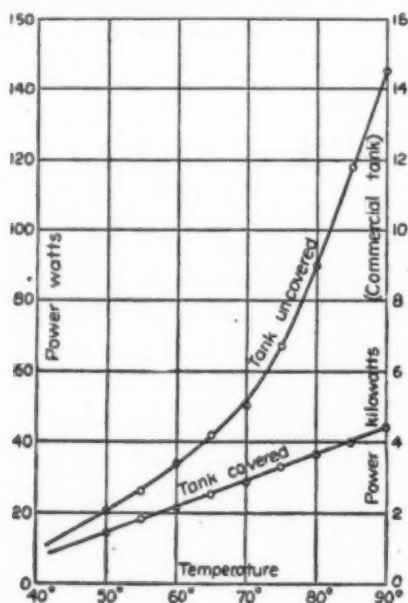


FIG. 1.—RADIATION RUN.

in the article in our November issue, he gives the results of some tests with ferro-titanium.

Electrolytic Copper Refining.—In our October issue (page 484) we published an abstract of Dr. W. D. BANCROFT'S American Electrochemical Society paper on "Electrolytic Copper Refining." We supplement this by the adjoining diagrams, which are reproduced from a paper of Messrs. F. J. SCHWAB and I. BAUM, published in the October number of the *Journal of Physical Chemistry*. It will be remembered that these gentlemen, under the direction of Prof. Bancroft, carried out the experiments on which the conclusions of the paper were based.

Fig. 1 gives the results of the radiation run. The abscissas represent the temperature in degrees Centigrade at which the electrolysis is carried out. The ordinates represent the electric power required to overcome the loss of heat by radiation and to maintain the temperature constant. It is here assumed

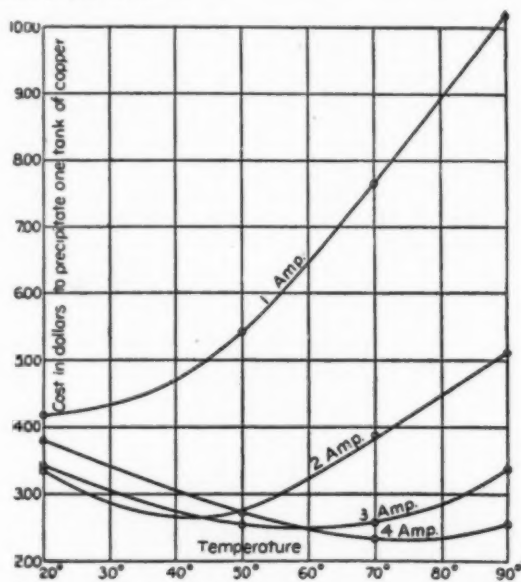


FIG. 2.—RELATION BETWEEN COST AND TEMPERATURE.

To arrive at a conclusion as to the most economical temperature and current density, two sets of curves were plotted which are shown in Fig. 2 and in Fig. 3. Fig. 2 shows the relation between the cost to precipitate one tank of copper and the operating temperature. Fig. 3 shows the relation between the cost to precipitate one tank of copper and the current density in amperes per square decimeter. All figures on which the calculation of these curves is based were already given in our last issue. But it may here again be emphasized that in the cost of precipitating one tank of copper only three items are included: the cost of depositing, the cost of heating, and the interest on copper.

Electroplating Upon and with Aluminium.—In our January issue an article was published by Burgess and Hambuechen, in which the problems of electroplating upon aluminium and electroplating with aluminium were discussed. Two articles giving interesting information on these subjects were recently published in other journals. The one by A. FISCHER deals with the electrodeposition upon aluminium. He remarks that in many cases it is a difficult matter to obtain a sound and adherent film of some foreign metal by electrodeposition upon ordinary aluminium. Various methods of procedure and numerous baths have been patented, but these are usually of little value. The porosity and irregular degree of purity possessed by commercial aluminium have also been offered as excuses for the troubles of the plater. The author offers the following suggestions as trustworthy: Coatings of copper, silver, nickel, zinc, and tin may be obtained directly upon aluminium; but films of gold, "brass," and arsenic are best applied upon substrata of copper, nickel, or silver. Aluminium coated with copper or silver can be "oxidized," and there will be no danger of the deposit coming off; but the use of hot liquids, and more particularly of hot solutions of alkali sulphites, must be

avoided, or the deposit may blister. If the aluminium has been tarnished by exposure to air, it should be cleaned by the process recommended by the Neuhausen factory. The articles are immersed for 15 seconds in a 10 per cent solution of caustic soda, which has been saturated with common salt, taken out, washed, rubbed with powdered pumice, dipped for another 20 seconds, treated with a German silver scratch-brush and dried. Aluminium containing copper should be dipped in nitric acid, or cleaned by heating. Before immersion in the electrodepositing bath the goods should be well cleaned with a bristle-brush and pumice. For coppering, the old bath, containing 100 grams of copper sulphate and 60 grams of nitric acid (sp. gr. about 1.3) dissolved in 1 liter of water works perfectly. A cyanide copper bath cannot be used, because it seriously attacks aluminium. The current density should be $ND_{100} = 1$ to 1.7 amperes, and the voltage 0.5 to 1.0. For silvering, Neesen's process is good. The aluminium articles are momentarily dipped in hot nitric acid, washed in water, soaked for a few minutes in 10 or 15 per cent caustic soda or potash, then put without washing into a solution containing 5 grams of mercuric chloride per liter, rinsed, dipped again in the alkali, and finally without rinsing put directly into the cyanide silver bath. A somewhat high pressure (about 2 volts) should be em-

attacked by very many experimenters, so that McDermott's method should be of interest, although he does not claim that this process is commercially practicable or even experimentally satisfactory. But he claims that by this method he can deposit aluminium from an aqueous solution upon copper, brass and iron, and probably other metals. A strong solution is made of ordinary copper sulphate, $CuSO_4 \cdot 5H_2O$, and from this the copper is completely precipitated by an excess of metallic aluminium, either with or without the aid of heat. Hydrogen is evolved during the precipitation, the reaction appearing to be $3CuSO_4 \cdot 5H_2O + 4Al = Al_2(SO_4)_3 \cdot Al_2O_3 + 3Cu + 6H + 2H_2O$. The clear solution remaining after the copper and impurities have been filtered off appears to be a solution of a basic sulphate of aluminium. The liquid has a bitter, alum-like taste, and is quite colorless. This is the solution from which the aluminium is deposited.

The article to be plated is thoroughly cleaned in the usual manner, and is, of course, made the cathode of the electrolytic cell. The anode is a plate of aluminium. One Grenet or Fuller cell furnishes ample voltage. The deposit obtained is of a dull lead color, which, however, changes to the ordinary appearance of polished aluminium under the burnisher. Hydrogen is evolved at the cathode during the passage of the current and another gas, presumably oxygen, appears at the anode. Both gases adhere to, and will eventually cover, the respective plates, unless removed by tapping or otherwise. The solution is an extremely poor conductor, and only a small current can be passed. The current density at which satisfactory deposition will take place seems fairly large, though he has made no definite measurement of it. If too strong a current is used, the deposit will be a non-adherent impalpable powder, or the hydroxide; if too weak, the deposit will be crystalline or granular, and will take place only in spots. He has never tried warming the solution, for, though this might increase its conductivity, it seems probable that it will cause the deposited metal to decompose the water. After having been used for some time the solution gives out, refusing to deposit the metal in any form save the hydroxide, acting in the same manner as a solution of the normal sulphate. Upon standing unused, the liquid precipitates the hydroxide and becomes unfit for use. The anode is corroded very unevenly, an effect presumably due to impurities.

THEORETICAL AND EXPERIMENTAL.

Solubility of Magnesium Carbonate in Aqueous Solutions of Certain Electrolytes.—Under this title F. K. CAMERON and A. SEIDELL, publish in the *Jour. of Phys. Chem.*, November, the results of an experimental investigation which are summed up as follows: When appreciable quantities of carbon dioxide are present in the vapor phase in contact with solid magnesium carbonate and solutions of other salts, there is a marked tendency toward conditions of false equilibria; the usual explanation advanced to account for these observations, that double carbonates are formed, is unsatisfactory. The solubility of magnesium carbonate in solutions of sodium chloride, when in contact with ordinary air, increases with increasing concentration of sodium chloride up to a maximum, and then decreases. The solubility of magnesium carbonate, as the bicarbonate, in solutions of sodium chloride when in contact with an atmosphere containing only carbon dioxide and water vapor at atmospheric pressure, decreases regularly with increasing concentration with respect to sodium chloride; this appears to be a real exception to the hypothesis of electrolytic dissociation for which no explanations based upon that hypothesis can be offered. The solubility of magnesium carbonate in solutions of sodium sulphate, in contact with an atmosphere containing only carbon dioxide and water, increases slightly and then decreases with increasing concentrations of sodium sulphate. In contact with an atmosphere free from carbon dioxide, the solubility of magnesium carbonate increases to a maximum, and then decreases, with increasing concentration of sodium chloride; it increases regularly with increasing con-

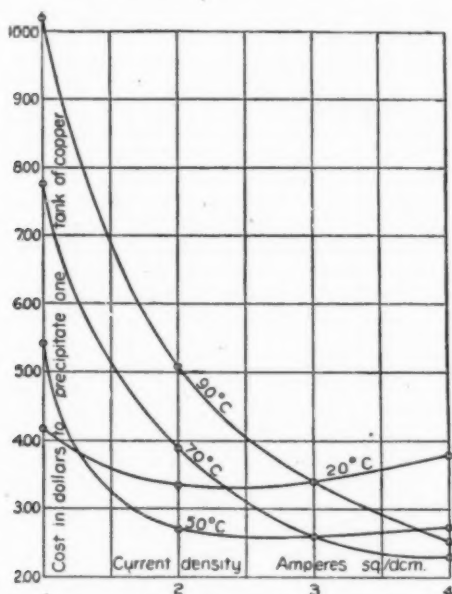


FIG. 3.—RELATION BETWEEN COST AND CURRENT DENSITY.

ployed at first. The deposit of silver adheres well, may be scratch-brushed and bears burnishing with steel and blood-stone. The nickel bath should contain nickel sulphate, 50 grams; ammonium chloride, 30 grams; water, 1 liter. Current $ND_{100} = 0.1$ to 0.15 ampere. In two or three hours the deposit is thick enough to bear polishing with oil and whiting. For tin the bath would be sodium pyrophosphate, 20 grams; fused stannous chloride, 8 grams; water, 1 liter. The voltage should be between 2 and 3. The film can be polished by scratch-brushing. For zinc the bath may be zinc sulphate, 180 grams; dry sodium sulphate, 50 grams; water, 1 liter. Voltage = 4. Many varieties of "magnalium" can also be coated by the methods described above. This note is taken from the London *Electrical Rev.*, October 30, the original article having been published in the *Chemiker Zeitung*.

In the November issue of the *American Electrician*, F. A. McDERMOTT describes the following method which enabled him to plate with aluminium. He has also sent us some special information. It is well known that this problem has been

centration with respect to either sodium sulphate or sodium carbonate. The solubility of magnesium carbonate in solutions of sodium sulphate, in contact with an atmosphere free from carbon dioxide, appears to decrease with increasing temperature. The solubility curve for magnesium carbonate in solutions of sodium carbonate is not in apparent accord with the theory of electrolytic dissociation.

Theory of Colloidal Solutions.—In an article on this subject, published in the *Comptes Rendus*, October 12, and abstracted in the *London Electrician*, October 30, PERRIN puts up the theory that every colloidal solution is made up of granules, which are invisible in the microscope, but much more bulky than the molecules, since they diffuse light considerably, and which are charged electrically, since they follow the lines of force in an electric field. The difficulty in the way of this conception lies in understanding why the larger granules do not absorb the smaller ones, as in rain clouds, how the granules can grow and diminish reversibly with the temperature, and how, at a certain limit, an irreversible coagulation can set in, especially under the influence of polyvalent ions. To account for the stable equilibrium, the author supposes that the surface tension and cohesion which lead to the formation of granules are counteracted by the electrification which acts in a dissociating sense, and that at a certain point these two opposing forces are in equilibrium. The author traces the development of a granule from the first conglomeration of atoms to the time when it contains two similar electrons which tend to produce a "segmentation" of the granule by their mutual repulsion. When the granule becomes very large, or when polyvalent ions are present, the chances are overwhelmingly in favor of an equal quantity of both electricities, in which case the granule becomes an electric doublet, and there is nothing to counteract the tendency to coagulate.

Chemical Apparatus Made from Fused Quartz.—A paper by H. HERAEUS is published in the *Zeit. f. Elektrochemie*, October 22, giving a history of the subject, and a summary of the author's achievements in this line. It is now possible to make any apparatus from fused quartz which can be made by the glass-blower from ordinary glass before the lamp. But the price of quartz apparatus is still comparatively high. The chemical and physical properties of quartz apparatus are discussed at some length. Quartz apparatus is not attacked by water, acids and salt solutions, but by alkaline liquids, and at high temperature by any oxide; it is not affected by rapid changes of temperature. Optically it is perfectly transparent to the ultraviolet part of the spectrum. For this reason interesting results may be expected from experiments with vacuum tubes, made from quartz.

Rotating Cathode for the Electrolytic Determination of Metals.—With reference to the recent work of Gooth and Medway, an improved apparatus for the electrolytic determination of metals with the aid of a rotating cathode is described by E. S. SHEPHERD in the *Journal of Phys. Chem.*, November. The novelty lies in the arrangement and, besides the rapidity of the test, its chief advantage is said to be a saving of at least 75 per cent in the weight of platinum.

Course in Electrochemistry.—In the *School of Mines Quarterly*, July, TUCKER gives some laboratory notes on exercises in practical electrochemistry, which were prepared for use in the electrical engineering department of Columbia University, to give the students familiarity in the practice of electrochemistry, and particularly in the use of the electric furnace. General instructions are given for the following exercises, some of the notes being illustrated by diagrams: Working of a copper liquid containing arsenic; electrolysis of salt solution with the use of a diaphragm; electrolysis of fused lead chloride; preparation of calcium carbide; laboratory experiments illustrating the principles of the Cowles process of making aluminium bronze, of the Acheson process for making carborundum, of the Hall process for making aluminium, and of the Moissan method of making metallic chromium.

PRIMARY AND STORAGE BATTERIES.

Electricity Direct from Carbon.—A summary of the present state of the problem of converting chemical energy of burning carbon directly into electricity is given by LORENZ in *Mittell. d. Phys. Ges. Zürich*, No. 5 (abstracted in the *London Electrician*, October 30). Slow combustion involved in the electrolytic process such as in an ordinary voltaic cell suffers under three disadvantages—viz., the slowness of the reaction between carbon and oxygen at ordinary temperatures, the impurity of the carbon, which gives rise to complicated hydrocarbons in solution and the necessity of using the highly-priced conducting forms of carbon instead of ordinary coal. These circumstances lead to the adoption of a gaseous "electrode" consisting of carbon monoxide, as in the cells of Bucher and Borchers. In these, however, the currents obtained cannot be proved to result from the further oxidation of the carbon monoxide. Indeed, the existence of carbon monoxide ions has yet to be demonstrated. Another, but more indirect way of utilizing the energy of carbon is that suggested by Nernst, in which carbon is used for regenerating other cells, such as a Daniell cell, by the reduction of the zinc sulphate. Another method proposed by Nernst is to heat an accumulator having a negative temperature coefficient until its e. m. f. disappears and then let it cool. Dolezalek has, indeed, obtained an e. m. f. of 0.6 volt between two lead accumulators having a difference of temperature of 90°. The problem is theoretically soluble, but will require much detail work for its final solution.

An interesting application of the principle mentioned above—to use carbon for regenerating the materials of a discharged primary battery, for instance, for reducing the zinc sulphate in a Daniell cell—is made by JONE in his "coal battery," about which some vague notes have repeatedly been published in recent years in the daily and technical press, but which is now described in full in the *Western Electrician*, of November 21. He uses, however, tin instead of zinc for the material of the positive electrode, for the reason that tin can be more easily reduced from its compounds than zinc. The other electrode is carbon and mercuric oxide is used as depolarizer. The electrolyte is a hot aqueous solution of caustic potash.

The cell is contained in a vessel of nickel-plated iron or nickel steel; in the same is placed a cylinder of tin. In the center of the cell a porous carbon cup is suspended which contains a layer of mercuric oxide. During discharge the tin is oxidized to stannous oxide, while the mercuric oxide is reduced to metallic mercury. (The cell thus acts as an "oxygen-lift" cell.) The e. m. f. of the cell is 1.06 volts.

The oxide of tin is reduced back to metallic tin in a reduction furnace, the waste gases from which are utilized to heat the cell. The mercury is changed back to mercuric oxide by first converting it into nitrate by treatment with nitric acid and then breaking the nitrate up by heat into mercuric oxide and nitrous vapors. The nitric acid is then recovered by oxidizing the nitrous vapors in the presence of steam and atmospheric oxygen. Thus, none of the reacting substances are used up except the coal and the oxygen of the air.

The author describes in detail the mechanical arrangements by which all the operations (discharge and regeneration of the substances) are carried on continuously and simultaneously. The efficiency of the whole cycle with an apparatus of several hundred horse-power capacity is claimed to be 66 per cent of the energy of the coal consumed (as against 10 per cent being the efficiency obtained by means of steam engine and dynamo). The author states that he has recently substituted a cheaper substance for mercury; his new depolarizer is reoxidized by atmospheric oxygen directly, so that the use of nitric acid is eliminated; no further details are given concerning this point. While he formerly used stirring apparatus, these are said now to be superfluous. Two opinions on the cell by Dr. Thurliman and Dr. Beyenbach of the Monadnock

School of Assaying, in the city of Chicago, are printed, partly in abstract.

For those who desire to verify the principal facts connected with the battery, the author gives the following directions. They relate, however, only to the discharge of the battery and not to the whole cycle.

A porous carbon cup can be bought ready-made. The cell known as the National No. III., made by the National Carbon Co., in Cleveland, Ohio, contains one. The cell vessel should be of iron, or, better still, nickel-plated iron. The electrolyte is made by dissolving two parts by weight of caustic potash in sticks in one part by weight of water. By keeping the cell at 160° C. and connecting the carbon cup into which are placed several ounces of mercuric oxide, by means of an "under-writer's" or a similar wire with non-combustible insulation, with a rod or plate of metallic tin dipping into the alkali solution, the voltage may be measured, and an idea obtained of the amperage. If the tin is weighed before and after the production of the current, the loss of weight indicates the energy expended in heat units, 118.0 grammes of tin, representing 67,700 small calories (gramme-degrees) if there is not enough alkali to dissolve the stannous oxide formed, and 70,700 small calories if there is enough alkali to dissolve the oxide. By measuring the watt-hours at the same time, the efficiency of the discharge of the cell may be calculated by converting the electrical energy obtained into the equivalent of heat and comparing the calories thus obtained with the calories expended. A small unit of electrical energy, or watt-second, is equal to 0.241 small calorie, as is well known. The efficiency obtained in this manner amounts to about 85 per cent. With a larger cell it is naturally higher. With the model with which the author has been working it is 95 per cent.

Alkaline Accumulators.—A general discussion of the advantages of alkaline cells is given by SCHMIDT in *Mitteil. d. Phys. Ges. Zürich* and abstracted in the *London Electrician*, October 30. Their chief merit lies in the fact that, apart from water, no constituent of the electrolyte enters into the reaction, so that a relatively small amount of electrolyte is required and the weight is reduced. The final result of the discharge may be described as a transference of oxygen from one electrode to the other electrode through the medium of water. The author points out that any metals whose oxides are insoluble in alkalies are suitable for electrodes in alkaline accumulators. Such are the ordinary metals cadmium, iron, nickel, copper, mercury and silver. Zinc oxides are soluble in alkalies, but not in alkaline silicates, aluminates or carbonates. Accumulators consisting of two electrodes of the same metal are most disadvantageous, since self-discharge by the accidental deposition of one metal upon the other is avoided. The difficulties encountered are mainly mechanical, and concern the mounting of the oxide in the shape of cohesive and yet porous masses. The oxide has to be prepared beforehand, as is done by Edison in his nickel-iron accumulator, and is contained in small metallic boxes closely packed. The oxide is utilized to a greater extent the nobler the metal. For silver the utilization reaches 100 per cent. The yield of Edison's

accumulator is now given as 25 watt-hours per kg., but the efficiency is stated to be less than that of lead accumulators and the price is higher.

MISCELLANEOUS.

The Influence of Electricity on the Development of Water Powers.—An interesting paper on this subject was read before the New England Cotton Manufacturers' Association by Dr. F. A. C. PERRINE, and has been printed in pamphlet form by this Association. In view of the increasing tendency of paper and pulp mills and similar concerns, especially in the New England States, to install their own electrolytic plants for making bleaching powder or hypochlorite, the question becomes important whether it is advisable for any mill to have its separate hydro-electric plant. Dr. Perrine remarks that many mills have been located on account of the availability of the valuable water-power and are to-day operating under great disadvantages from their inaccessibility, rendering necessary a heavy teaming bill for the haulage of raw material, finished product and coal. In order to permit an arrangement of the mill which will connect the machinery properly to the water-wheel, it frequently happens that they are located at sites entailing expensive original construction and unsatisfactory internal arrangements; besides, the location along the streams often gives rise to great repair bills in times of flood, and, finally, in such locations neither mills nor tenements are properly situated with reference to the best sanitary conditions.

Dr. Perrine brings forward the idea of the centralized plant, developing power for the use of many cotton mills, as he believes that the manufacture of the power should not be considered one of the provinces of a cotton mill superintendent. In many cases, this means the purchase of power from an altogether independent concern from the mill itself, though in many cases he hopes in the future to see central power plants owned by the cotton mills, precisely as they own their insurance companies to-day, with a separate and efficient management, and with a common interest and aim. Dr. Perrine therefore advocates the development by means of long flumes in large central power stations of as many rapidly-flowing streams as are available; the development of streams that, by reason of their distance from satisfactory factory sites have heretofore been considered unavailable; the increase of size of the power plants, and the uniting under one management as many power plants as possible; as well as the operation under the same management of steam auxiliaries necessary for the development of constant power; the abandonment by the cotton manufacturers, as far as is consistent with present conditions of the generation of power as a part of their regular business, and the placing of this work in the hands of experts who will install the machinery, make the power and deliver it to the mill for the operation of their dynamos, the location of the mills themselves at points adapted entirely to their manufacture, taking into account both the accessibility to railroads and the comfort and convenience of their employees.

On account of limitations of space we have to reserve a larger number of abstracts for our next issue.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Electric Furnace.—H. Harmet, St. Etienne, France. Patent 742,315, October 27, 1903. Application filed November 29, 1901.

Harmet's furnace is composed of three parts, a fusion chamber, a reduction chamber and a refining oven. The fusion chamber has a conical shape, widening towards its bottom. The bottom is sloping towards the reduction chamber and in-

clined electrodes are supported upon it. The fusion of the oxides is mostly caused by the gases coming from the reducing chamber, the function of the electrodes in the fusion chamber being merely to serve as auxiliaries in the production of heat. The reducing part of the apparatus consists essentially in a horizontal furnace, having a vertical charging chamber at the end towards the refining oven. This charging chamber is filled with coke or charcoal, the column of which

rests on the bottom of the reducing oven. The reduction is said to take place as follows: A first layer of metal collects upon the sole of the furnace; on top of this swims a layer of incompletely reduced oxides, more or less mixed with a third layer of slag. The main column of coke rests on the sole of the crucible, but fragments of it are lifted and float upon the mass. The melted oxides discharged from the fusion chamber fall upon this mixture of coke and slag and are reduced under the influence of the high temperature produced by the current, which is introduced through two carbon electrodes. Before the reduced metal or slag can be tapped, they must both pass through the column of highly incandescent carbon, which perfects the reduction. The crucible is provided with openings for tapping the reduced metal and the slag. The former passes into a third crucible of preferably circular cross-section, where it is heated by an electric current introduced through two carbon electrodes, and is refined in a manner analogous to that in the Martin furnace. The specification seems to de-

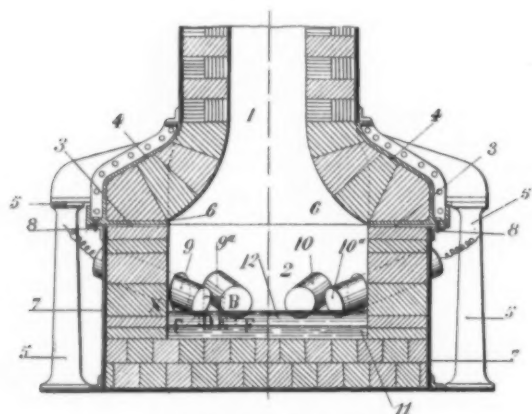


FIG. 1.—HARMET FURNACE.

scribe essentially the same method of procedure, as is well known, from Harmet's foreign patents.

Electrometallurgy of Iron and Steel.—H. Harmet, St Etienne, France. Patent 742,316, October 27, 1903. Application filed originally November 29, 1901. Divided and refiled August 6, 1902.

The specification protects the method of procedure for the electrical smelting of iron and steel outlined above and carried out in the above apparatus.

Electric Furnace.—H. Harmet, St. Etienne, France. Patent 742,419, October 27, 1903. Application filed February 20, 1903.

The furnace described in the specification is a modification of the arrangement of the reducer mentioned above in describing the inventor's process. It has the purpose of facilitating the arrangement of a large number of pairs of electrodes, and of preventing the passage of current through the liquid metal. It consists of two portions, 1, 2, which are separated by the joint 3. The upper portion is formed of a metal casing 4, supported by pillars 5, the rib 6 supporting all the masonry. The crucible is formed of a metal casing 7, independent of and not supporting the upper casing. The electrodes are arranged in groups, each group serving for the passage of a separate current; thus, the two electrodes 9, 9a work together, 10, 10a, etc. The metal 11, below the slag 12, is strongly heated by its passage through the latter. All heat is communicated to the slag, which serves as resistance. The electrodes of a current, f. e. 9 and 9a, are given two movements, one axial, allowing the lower end to be placed nearer to, or farther from, the slag, and the other a slight oscillatory movement.

Electric Furnace.—F. E. J. Hatch, Greenbay, Wis. Patent 741,333, October 13, 1903. Application filed December 4, 1902.

The furnace consists essentially of a cylinder of metal or other suitable material, lined with firebrick or other refractory materials. A number of straight tubes of porcelain or another highly refractory material pass through the cylinder lining, parallel with the axis and close to the interior surface of the lining. These tubes are open at both ends, and filled with a number of small cylindrical carbon blocks, which serve as conductors of the current. Suitable means are provided at the ends of the tube, to exert pressure upon the carbon blocks and to thus keep them in close proximity to each other.

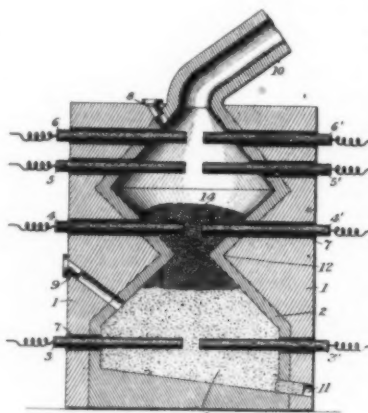


FIG. 2.—FURNACE FOR PRODUCING CHLORIDES OF CARBON.

Powdered carbon may also be used instead of the cylindrical blocks. A modified construction is shown, in which the tubes are so disposed as to be flush with the surface of the firebrick lining, and are cut away so as to expose a part of the carbon conductors.

Process of Producing Chlorides of Carbon.—F. J. Machalske, Brooklyn. Patent 742,340, October 27, 1903. Application filed June 18, 1903.

The process is carried out in the apparatus illustrated in Fig. 2. The preferred mode of operation consists in charging a mixture of sodium chloride and silica 13 into the lower part of the furnace. The mixture is then heated by an electric current passing through the electrodes 3, 3', when the sodium chloride melts and the silica reacts with it, liberating the chlorine. The latter rises through a column of coke 14, which is kept in a state of incandescence by the electrodes 4, 4', and forms the various chlorides of carbon, according as the proportions of the ingredients of the charge are varied, or the number of electric arcs in the furnace chamber above the charge. The furnace stack is lined with magnesia brick, and has charging openings 8, 9, a tapping hole 11, and an outlet flue 10. The temperature required for the reaction is stated to be somewhat below 2000° C., an electric current of 500 amperes at sixty volts being sufficient for a furnace of the usual size. Sulphur chloride may be produced simultaneously by adding sulphur to the charge. The upper arcs, above the charge, serve to modify the composition of the chloride of carbon, by reducing them to a lower state, according to the equations: $\text{CCl}_4 + \text{C} = 2\text{C}_2\text{Cl}_2$; $\text{CCl}_4 + \text{C} = \text{C}_2\text{Cl}_4$. They also serve to bind any uncombined chlorine present in the gaseous carbon compounds.

Production of Nitrogen Compounds.—G. de Chalmot, Leaks-ville, N. C. Patent 741,396, October 13, 1903. Application filed Jan. 23, 1896.

The invention relates to the production of nitrides of metals or metalloids in the electric furnace and the production of ammonia from them. Nitrogen is forced through the incandescent materials, which are mixed with an excess of carbon in order to prevent the resulting molten mass from becoming too fluid and to render it porous. The material which the inventor preferably employs is titanium oxide or a high-grade titaniferous ore. This is pulverized and mixed with a basic oxide, preferably caustic lime, and a carbonaceous material,

preferably coke or charcoal. This mixture is then submitted to the electric arc in a furnace shown in Fig. 3. It consists of a long stack A, which contains in its upper part the furnace chamber B. Electrodes C, C are introduced into the latter. A hopper A with slide E serves to feed the raw material into the furnace. The inventor prefers to introduce the nitrogen in the form of producer gas chiefly a mixture of nitrogen and carbon monoxide. The producer gas is admitted through pipe I. and is drawn through the furnace by means of a suction blower. Openings a, a are provided in the lower part of the furnace for passing in superheated steam, which decomposes the nitrides, generating ammonia. The gases pass out of the furnace through perforated pipes b, b, of porcelain or metal, which are arranged to be water-cooled in the latter case. Through openings C in the walls of the furnace, the gases are conducted to the pipe d, which leads them to the purification and ammonia absorption apparatus. The apparatus is constructed for a quasi-continuous running by providing it with a movable bottom g, and the necessary mechanism, shown in the illustration, by which that bottom can be gradually lowered and fresh material brought between the carbons. Other oxides than that of titanium may be used and alumina is stated to have given especially favorable results.

APPARATUS AND PROCESSES FOR THE ELECTROLYTIC PRODUCTION OF METALS AND COMPOUNDS.

Process of Treating Cyanide Solutions.—W. H. Davis, Boulder, Col. Patent 741,231, October 13, 1903. Application filed July 3, 1902.

The invention relates to the extraction of gold and silver from ores by the cyanide process. The inventor proposes to add an alkaline hydrate to the contents of the cyanide storage or leaching tanks, and then to subject the mixture to the action of an alternating current. In most cases the process is said to be applied to solutions, after their values have been precipitated. The electrodes are stated to be preferably of lead, and the solution is subjected to an alternating current of a strength predetermined according to the amount of solution in the tank. The inventor states further that the distance apart at which the electrodes are placed is a factor of the cycle of the current, and must likewise be determined for each particular case. The data of the alternating current are specified by the inventor as follows: "The volume of the current used may be from 0.01 to 0.04 amperes per ton of solution,

P
and the voltage in accordance with Ohm's law $= \frac{P}{R} = C$ (!).
R

With regard to the number of cycles admissible for ordinary commercial use, from sixty to 120 have been tried and are satisfactory." When the current is applied to the solution, while contained in a solution tank, the hydrates of the metals, such as mercury, copper, arsenic, antimony, iron, aluminium, chromium, manganese, cobalt, nickel and magnesium are said to fall as precipitates to the bottom of the tank; all these metals are stated to have been found by analysis to have been precipitated by the process.

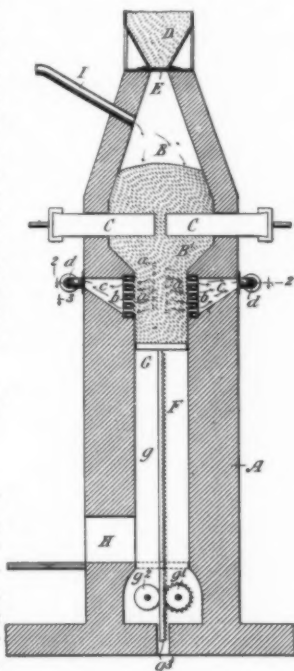


FIG. 3.—PRODUCTION OF NITROGEN COMPOUNDS.

Process of Treating Ores.—C. E. Baker and A. W. Burwell, Cleveland, Ohio. Patent 741,439, October 13, 1903. Application filed December 23, 1902.

The process is said to be especially intended for pyritic ores of nickel and copper, like the Sudbury ores. The first step is the chlorination of the ore, which is carried out in a revolving drum, lined with porcelain or lead, through one of the hollow trunnions of which the chlorine is introduced. The ore is crushed to about fifty mesh, and the drum filled one-third with it. A chamber of boiler iron, with an interior covering of asbestos, surrounds the drum, and is provided with an inlet at the bottom, for the purpose of introducing waste products of combustion, which are intended to heat the contents of the drum to about 150° C. Sulphuryl chloride is stated to be evolved under these conditions, which is carried off through the other hollow trunnion of the drum into suitable condensing apparatus. Care should be taken to stop the introduction of chlorine gas the moment all sulphur is removed, in order not to effect the conversion of FeCl₂ into FeCl₃, which might be driven off with the S₂Cl₂. The residual mass is then tested with water to bring the chlorides into solution, and a sulphate or sulphuric acid is added to convert the metallic chlorides into sulphate. It is then proposed to subject the solution to electrolysis, using an electromotive force low enough to deposit only the copper. It is then neutralized and the nickel deposited with a current density insufficient to effect the deposition of iron; previous to the deposition of the nickel, however, it is proposed to add ammonium oxalate or "other salt" to the solution, to convert the nickel sulphate into "such double nickel salt as may be desirable for electrolysis." As a final step it is proposed to electrodeposit the iron remaining in the solution, briquet it and melt it down.

Electrolytic Diaphragm.—T. L. Roberts, New York. Patent 741,592, October 13, 1903. Application filed March 7, 1903.

The specification describes a diaphragm consisting of glass cloth, the interstices of which are filled with gelatinous material. The glass cloth is woven of very finely spun filaments of glass, a large number of which compose each thread of the warp and woof. The preferred method of treating the diaphragm is to place it into the battery before it is impregnated, and then to fill the compartments on either side with a solution of sodium silicate. The latter is allowed to remain until all the interstices of the diaphragm are filled. It is then removed and a dilute solution of sulphuric or hydrochloric acid put in its place, until, after a little while, the silicate will be gelatinized, after which the acid is removed.

Electrolytic Decomposition of Alkaline Salts.—Meyer Wildermann, London, England. Patent 741,864, October 20, 1903. Application filed May 5, 1902.

The cell described in the specification belongs to the mercury type of cells for alkali chloride electrolysis, and several modifications are shown. The first apparatus is a rectangular one, being divided into three compartments by two series of superimposed troughs, fitted with mercury to a certain height. Each trough has at its lower surface a thin rib, which dips into the mercury of the next lower one, thus bringing half of the mercury in the troughs into the centrally arranged anode compartment. Carbon electrodes are introduced into the latter, resting on the bottom of the apparatus. With a previous apparatus the inventor has found difficulty in getting the amalgam of sodium, which was formed in the central compartment, to travel by diffusion into the outer compartments, where it is to be discharged and caustic soda formed. For this reason he proposes in this apparatus to effect the transference of the amalgam, a series of ebonite blades, provided with teeth or projections, which dip into the mercury on the decomposing side of the apparatus and are fastened uprights, which can be given a reciprocating motion. The inventor discharges his amalgam by placing small particles of carbon around which one or more fine pieces of wire have been wound. He states that there is thus produced a num-

ber of small local decomposing cells on the surface of the amalgam, and the decomposition of the alkali metal amalgam proceeds very quickly. The mercury seal in the troughs is preferably seven to ten millimeters deep. The inventor states that he can operate the cells under much more unfavorable conditions than should be allowed in practice, with a current density of twenty-five amperes per square decimeter at a voltage not exceeding 6.5. He finds it practicable to employ in continuous working only from 48 to 60 grams of mercury

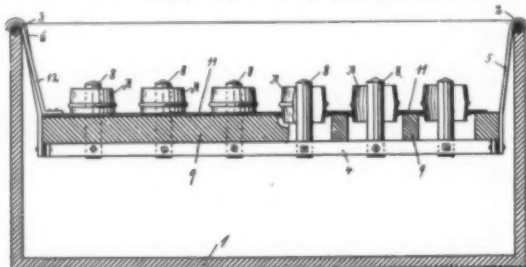


FIG. 4.—APPARATUS FOR ELECTROPLATING.

per ampere. He seems to think that the above is a high current density. As regards the voltage, it is hardly likely that a process using such high voltage for aqueous solutions could compete with the successful processes in use at present.

Apparatus for Electroplating.—C. T. Pratt, Frankfort, N. Y. Patent 742,131, October 20, 1903. Application filed July 6, 1903.

The apparatus which is illustrated in cross-section in Fig. 4 is especially designed for the electroplating of slip-nipples with zinc, with the bulk of the deposit on the interior surface. The apparatus consists of a rectangular tank 1, in which is suspended an anode rack 4, constructed out of a number of parallel bars with connecting bars at the ends. The zinc anodes 8 are suitably connected at regular intervals to these bars and project upwards. On top of the anode rack rests a spacing board 9 of insulating material, provided with large holes, which surround the anodes. On top of the board 9 there is arranged a metallic sheet 11, with smaller holes than those in the spacing board. The edges of these holes are preferably notched, so as to form a spring edge, which serves to hold the nipple to be plated, when it is inserted into the hole. The sheet 11 is connected to the anode by means of hanger 12, while the anode rack is in communication with the positive conductor 2 by means of hanger 2. The whole structure is readily accessible for the purpose of replacing or repairing.

Apparatus for Electroplating.—A. R. Pritchard, Rochester, N. Y. Patent 741,274, October 13, 1903. Application filed June 23, 1903.

The invention relates to a device for plating parts of sheet metal-ware vessels on one side only. It consists mainly of fastening two of these shapes back to back, with a metal plate between them, which serves at the same time as conductor of the current.

Electrolytic Reduction of Organic Compounds by Means of Titanium Compounds.—M. Moest, H. Hertlein, E. Oppermann, Höchst-on-the-Main, Assignors to Farbwerke, vormals Meister, Lucius und Brüning. Patent 742,797, October 27, 1903. Application filed July 14, 1903.

The inventors have found that when a titanous solution, f. i., a solution of titanous sulphate acidified with sulphuric acid, is electrolyzed without a diaphragm, with a lead cathode and platinum anode, the whole of the hydrogen at the cathode is first used to reduce the titanous salt, while the corresponding amount of oxygen escapes at the anode. The yield is first quantitative, then decreases as the proportion of titanous salt increases, and finally no further reduction occurs. If, however, a substance capable of reduction is introduced simul-

taneously, f. i., finely-divided azo-benzene, then the titanous salt formed at the cathode is at once reoxidized by the conversion of the azo-benzene into bensidine, which is precipitated as sulphate. The organic substance serves as receiver for the electrolytic hydrogen. Thus, the proportion of the titanous salt compared with that of the titanous salt remains very small, so that the yield is favorable, although no diaphragm is used. As a practical application the process is carried out in a vessel lined with lead and serving as cathode. It contains sulphuric acid with any quantity, f. i., two per cent, of titanous sulphate dissolved in it. Any first-class conductor which is not attacked may serve as anode. The circuit is closed, and a concentrated solution of ortho-nitro-para-cresol-ortho-sulphonate of sodium is introduced, with stirring it, at a moderate temperature. The introduction is best regulated in such a manner as to always leave some titanous compound in the electrolyte. Part of the amido compound formed is directly precipitated, and the remainder obtained by concentrating the electrolyte. The whole is then filtered and the electrolyte may be used for another operation. The reduction of nitrobenzene to aniline is carried out in the following manner: Fifty liters of hydrochloric acid of 3 per cent strength, containing a solution of about one to two per cent of titanium chloride are introduced into the cathode compartment of a cell, one kilo of nitrobenzene and 600 cc. of alcohol being stirred into it. The anode compartment contains an acidified solution of common salt. Any first-class conductors which are not essentially attacked, may be used as electrodes. The electrolysis is conducted without heating, and with a current density of 3 to 6 amperes per square meter. As soon as somewhat more than the theoretical quantity of current is used, the process is interrupted, and the anilin, which is obtained in excellent yield, is isolated in the usual manner. The reduction of azo-benzene to bensidine and the reduction of quinones are also described.

GALVANIC CELLS.

Electric Battery. H. Halsey, New York. Patent 735,971, August 11, 1903. Application filed April 18, 1902.

This is another form of the well-known type of battery of this inventor, in which mechanical movement is resorted to for bringing about a continuous circulation of the electrolyte. In the present instance, circulation is maintained by air, which is introduced at the bottom of the containing vessel under pressure. The cell itself drives a motor, which in turn actuates a blower for the purpose of furnishing the necessary air. It is claimed that polarization is prevented in this way.

Electric Battery. H. Halsey, New York. Patent 736,248, August 11, 1903. Application filed April 18, 1902. Divided and refiled December 13, 1902.

The present invention provides a receptacle for feeding a depolarizing fluid to a battery electrolyte. It consists essentially of a reservoir having a series of nozzles. In each of these nozzles is contained a core of blotting paper or another absorbent material of high capillarity. This allows the depolarizing liquid to be gradually fed to the electrolyte.

Electric Battery. H. Halsey, New York. Patent 737,613, September 1, 1903. Application filed December 6, 1902.

In this specification the inventor describes a new departure in connection with his cells, which contain movable electrodes. He now proposes to seal the cell hermetically and to exhaust the gases from it by an air pump. Outside of the movable electrodes he puts an asbestos diaphragm which has perforations to allow of the circulation of the electrolyte. This at the top is attached to a hollow hanger, which communicates by a pipe with the air pump. He states that "by the use of a porous diaphragm in a partial vacuum, the gases will be carried off more readily from the bottom, as they will be drawn into the interstices of the diaphragm and directly up through it by the exhaust, which will not be strong enough to draw up the liquid."

Electric Battery. H. Halsey, New York. Patent 737,614. September 1, 1903. Application filed December 6, 1902.

In the present form of battery provision is made for moving both electrodes. For this purpose they are both made tubular, and one of them placed inside of the other. They are supported upon shafts which pass through the sides of the containing vessel, each of which shafts is in connection with an electric motor, from which it is driven. The power to drive the motor is, of course, as in the other constructions of the inventor, furnished by the battery itself. The cylindrical electrodes move in opposite directions.

MISCELLANEOUS.

Process of Electrolytically Preparing Lithographic Plates.

O. C. Strecker, Darmstadt, Germany. Patent 737,882. September 1, 1903. Application filed April 19, 1900. Divided and refiled April 19, 1902.

The invention consists in employing electrolysis for the purpose of coating metallic plates with a layer of hygroscopic materials, in order to prepare them for printing purposes. The process is carried out in the following manner: A metallic plate, preferably of zinc or aluminium, but also of copper, nickel or alloys of them with former, is ground, rinsed with water and dried and a lithographic design, the negative of the intended print, is fixed on it. The plate is then gummed with a solution of gum arabic, dried, and the greasy substance is washed out by lithophene, a solution consisting chiefly of asphaltum in benzene or spirits of turpentine. The excess is wiped off and the plate dried; then the gum arabic is washed off the plate with water, and the lithographic design is left on the plate as a layer of asphaltum. After cleaning and correcting the plate, it is ready for the electrolytic process. Electrolysis is either carried out by suspending the plate in an electrolyte and passing the current or by arranging it horizontally, connecting it with the source of electricity, covering it with the electrolyte and then rubbing over it with the other electrode, which in this case consists of a metal plate provided with an insulated handle and faced with a layer of cotton four to five millimeters thick. The plate is subjected to the influence of an alternating current, the intensity of which is 0.1 ampere to 4 square inches, which latter is the size of the electrode opposed to the plate under treatment. The duration of treatment is five to ten minutes, the voltage not exceeding two volts generally, the frequency being about fifty to sixty. The electrolyte may consist of a solution of 3 per cent of a neutral phosphate, sulphate or the like. The passing of the current produces on the printing plate a layer, insoluble in water, which is stated to be probably the oxide or hydroxide of the metals employed. The character of the layer will be either neutral or basic, and as such would be useless for printing purposes, as it would attract the color or ink instead of the water, and cause the printing paper to grease up. The layer must, therefore, be heated with weak acids, or with substances like acid phosphate of ammonia, acid fluoride of ammonia, or silicofluoride of ammonia, the acids of which will form insoluble salts with the metals employed. In the case of a zinc plate the solution consists of ninety parts of water, six parts of gum, two parts of nitrate of ammonia and two parts of silicofluoride of ammonia.

Method of Cleaning Filters. T. J. Zoeller, Nashville, Tenn. Patent 736,669, August 18, 1903. Application filed June 7, 1901.

The inventor proposes to apply the electric current for the removal of silt and similar deposits from porous filter plates. The passage of the current gives rise to the formation of gases, which are relied upon to clean the plates. The inventor preferably first connects the positive pole of the battery with the plate to be cleaned, and the oxygen liberated on the application of the current is said to loosen the deposit. The current is then reversed in order to effect the liberation of hydrogen, which, occupying a larger volume, is said to force off or

strip the deposit from the plates. After this operation is gone through with, the current is reversed again in order to cause the liberation and occlusion of oxygen in the plates, and to oxidize the organic matter. Alternating current may also be employed.

Process of Decomposing Water by Electrolysis. W. F. M. McCarty, Rocky Ridge, Md. Patent 736,868, August 18, 1903. Application filed April 22, 1902.

The inventor proposes to make the water more conductive by the addition of tartrate of potassium, tartrate of sodium, or any of the citrates or other equivalents, and sulphuric acid. The quantity is one pound each of potassium and sodium tartrate, to each ton of 2000 pounds of water, and after these have thoroughly dissolved, sufficient sulphuric acid of 66° Bé. is added to make the water a one five-hundredths solution. The apparatus is a very simple one, consisting merely of two tanks connected about at half their height by a pipe. Sheets of platinum are used as electrodes. The tartrates are dissolved first, and the solution run into the electrolytic vessel; the sulphuric acid is then introduced. The following is the inventor's idea of the reactions taking place: "When the salts come into contact with the sulphuric acid, the water at first gives up a portion of its oxygen (!) to form carbonic acid gas, which is allowed to escape. This leaves the water more susceptible to the action of the current (!) which is turned on at the moment of ebullition of the water, caused by the decomposition of the salts on the addition of the acid." A little later he makes the remarkable statement, that the action of the salts, which are added, on the water renders it possible to use a current of much less strength (!) than is required where pure water forms the electrolyte. The apparatus, as shown in the sketch accompanying the specification, will need a good deal of development before it will be a serious rival of those of Garuti, Schmidt or Schoop. In place of sulphuric acid, tartaric, citric or acetic acid may be used, on paper, but probably not in practice, if the profit from the sale of the gases is not to figure on the wrong side of the cost sheet.

Apparatus for the Purification of Water. S. S. Pridham, Newark, N. J. Patent 735,817, August 11, 1903. Application filed July 20, 1901.

The apparatus described in the specification under consideration consists of a rectangular wooden tank, provided on the inner surfaces of the longitudinal sides with cleats, between which the electrodes are arranged, the cathodes and anodes being disposed alternately. The electrodes are of such size, that they fill out the cross-section of the tank and rest on the bottom. Communication between the various compartments thus formed is secured by means of rectangular openings cut out at one side of the tank from the anodes, and at the other side from the cathodes. The electrolyte, therefore, has to pursue a winding path on its travel through the apparatus. The arrangement of electrical connections for the apparatus is described in detail. The invention seems to consist primarily in a novel electrode, consisting of an alloy of magnesium and aluminium, the best results being obtained by the employment of an alloy of about 95 per cent magnesium and 5 per cent of aluminium. The apparatus is also intended for the defecation of sewage.

Process of Generating Electricity. J. H. Reid, East Orange, N. J. Patent 736,016, August 11, 1903. Application filed May 17, 1902.

The object of the invention is to develop electric energy from gas. The inventor describes a series of apparatus, the first ones being adapted for the utilization of illuminating gas, while several types are shown which use the gaseous products of combustion from a fire, and one in which a coal gas retort is placed in close proximity to the furnace. The simplest form of apparatus consists essentially of a cylindrical vessel of cast-iron, which flares out somewhat in the shape of a funnel at its upper end. It is suspended over a gasburner and filled with

molten sodium or potassium hydrate. The latter is maintained at a temperature of something like 400° F. A hollow chamber is suspended into the electrolyte, resting on insulating brackets. It is composed of porous carbon, and its interior communicates with the supply of gas. Close to the wall of the iron vessel a tube reaches nearly to the bottom of the electrolyte, for the purpose of introducing air into the electrolyte. The carbon chamber is of positive and the iron pot of negative polarity. When fuel gas is forced into the porous chamber, the author believes that it percolates through the porous walls, which are permeable to a gas, but not to a liquid. The carbon and hydrogen of the gas are believed to unite with the oxygen in the electrolyte or in the porous carbon wall. A production or development of electricity follows and will continue as long as the gas is supplied to one side of the porous carbon chamber and oxygen to the electrolyte on the other side. The porous carbon electrode which the inventor uses at the present time is of carbon, manufactured in the electric furnace, and had not shown any deterioration after twenty-one days of continuous usage. The inventor is unable to give the exact amount of gas consumed for each electrical unit developed, but is convinced that the quantity of gas fuel consumed is not greater than would be required for developing a similar amount of energy under a steam boiler and transforming the energy into electricity by means of an engine and dynamo.

Gas Battery. J. H. Reid, Newark, N. J. Patent 736,017, August 11, 1903. Application filed December 20, 1902.

The battery is illustrated in the adjoining figure. A casing of preferably cast metal 1 is filled with an electrolyte of hydrate of sodium or potassium at a temperature of 392° F. The

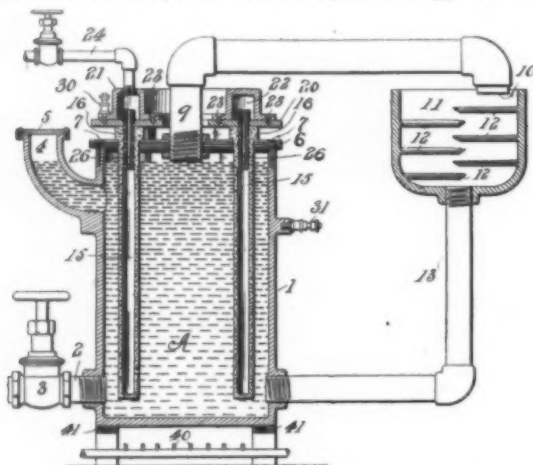


FIG. 5.—GAS BATTERY.

electrolyte is kept molten by means of a gas burner 40. Supported by an insulating cover 6, a number of porous carbon tubes 15, closed at the bottom, are suspended in the electrolyte. A collar 16 near the top of each tube makes a close joint with the cover 6. The tubes communicate with the gas supply through pipe 24 and the annular cap 21, and its channel 22. When the electrolyte, which contains a considerable amount of oxygen, is heated to the proper temperature, and it is desired to develop electrical energy, a fuel gas is introduced under pressure into the annular chamber 22. The gas is driven down into the porous tubes 15 and percolates through them. The electrolyte immediately begins to froth, and a portion of it is driven through pipe 9 into the funnel 11, being in its passage exposed to the air. It runs over the baffle-plates 12, and returns through pipe 13. A development of electrical energy follows, and can be obtained by making connections at 30 and 31. Replenishing of the electrolyte takes place through opening 4.

Process of Treating Animal Hides or Skins. G. D. Burton, Boston. Patent 739,825, September 29, 1903. Application filed November 8, 1898.

The inventor uses a rectangular vat, with the positive electrode at one end and the negative electrode at the other end of the vat. A screen of perforated wood or other insulating material is arranged in front of the electrodes. Rods run longitudinally through the tank from one screen to the other, below the level of the solution. The hides to be tanned are hung over them with their hair sides outward. Air is blown into the vat for circulation purposes. A current of from six to five hundred volts, and from five to five hundred amperes is said to be passed, depending on the size of tank, quantity of solution and number of hides. Electrolytic treatment for thirty minutes in the unhairing solution suffices in some cases. The skins are then drenched, and returned to the tank, which is then filled with a tanning solution. They are then again subjected to electrolysis. The best results are stated to have been obtained with a lead plate serving as anode and a copper cathode.

Apparatus for Treating Gases. H. Pauling, Brandau, Austria Hungary. Patent 739,920, September 29, 1903. Application filed April 2, 1902.

The specification describes an apparatus principally designed for the nitrification of atmospheric air. The principle of the apparatus is shown in the accompanying figure. The leading idea has been to act upon all parts of a given volume

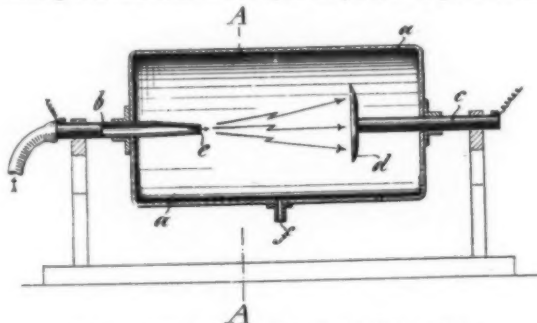


FIG. 6.—APPARATUS FOR TREATING GASES.

of gas, instead of only on a small fraction of it at a time, as would be the case between ordinary electrodes. The apparatus consists of a cylinder a, in which the two electrodes b and c are mounted axially and insulated from the cylinder. The electrodes are tubular and connected with the poles of an induction coil. The positive electrode b terminates in a nozzle, while the negative electrode c carries a disc d. The gas to be treated is blown through b, and as the jumping of the spark takes place in the shape of a cone, the greater part of the gas current coincides with the spark path. The gases which have been subjected to treatment are sucked out of the cylinder a by means of pipe c, and passed on for further treatment. The gases to be treated can be subjected to the treatment in a more or less cooled or heated state, and under normal, increased or reduced pressure.

Apparatus for Treating Gases. H. Pauling, Brandau. Patent 739,921, September 29, 1903. Application filed April 2, 1902.

This apparatus is intended for the same purpose as the preceding one. The construction, however, is different, in so far as it has been the aim of the inventor to produce a sparking surface drawn out in band shape. He accomplishes this by mounting a wire in the form of a spiral, on the surface of a rotating cylinder of insulating material. The wire is connected to one pole of an induction coil, while a straight bar, parallel to the cylinder, serves as the other pole. If the speed of rotation of the cylinder is sufficiently great, a continuous spark-band is produced between the wire on the cylinder and the bar. A set of nozzles delivers the air right between the

bar and the cylinder. The apparatus is enclosed in a suitable casing, and, like the preceding one, can be adapted to varying degrees of temperature and pressure.

CURRENT NOTES.

MADISON LOCAL SECTION OF THE AMERICAN ELECTROCHEMICAL SOCIETY.—The first local section of the American Electrochemical Society has been organized at Madison, Wis., with a dozen members. On account of the interest shown in this movement, it is expected that the membership of this section will considerably increase during the next months.

NEW YORK LOCAL SECTION OF THE AMERICAN ELECTROCHEMICAL SOCIETY.—The executive committee of this section will consist of Messrs. G. A. Doremus, chairman; Alois von Isakovics, secretary; C. O. Mailloux, W. Asa McCoy, and E. F. Roerber. A meeting of the executive committee is called for November 30, and the first meeting of the section will be held shortly afterwards.

LEHIGH VALLEY SECTION OF THE AMERICAN CHEMICAL SOCIETY.—We are informed by the secretary, Mr. W. S. Landis, that the Lehigh Valley section of the American Chemical Society met in the lecture room of Gayley Laboratory, at Lafayette College, Easton, on November 18, Prof. J. W. Richards presiding. The officers elected for the ensuing year are Mr. Porter W. Shimer, of Easton, chairman; Mr. Walter S. Landis, of Lehigh University, secretary, and Mr. Richard K. Meade, of Easton, representative of the section on the Council of the Society. The papers read and discussed were as follows: Compressive Strength of Cement, by Prof. Mansfield Merriman; on cement tests, by Mr. Ernest B. McCready; fuel efficiency of the rotary kiln, by Prof. J. W. Richards; the fallacy of the tests ordinarily applied to Portland cement, by Mr. Richard K. Meade; geology of the cement belt in Lehigh and Northampton Counties, Penn., by Prof. F. B. Peck. The meeting was one of the most successful ever held by the section, the cement industries of the valley being very fully represented.

RHODIN PROCESS.—The receiver of the American Alkali Co., which owns and formerly had in operation the Rhodin process for making caustic alkali and bleach, recently called on the holders of preferred stock for an additional assessment—the preferred stock having paid 20 per cent at the time of the organization of the company. The additional assessment was resisted by several of the stockholders, among them Messrs. Salom and Morris of Philadelphia, and suit was brought by the company against Messrs. Salom and Morris, and others. The defence of the latter was that the original representations under which the subscriptions were obtained, were misleading, as far as the statements in relation to paying the Commercial Development Co. certain sums of money, and stock for the patents, and so far as the basic nature of the patents themselves were concerned. The case was recently tried in Philadelphia and the jury decided in favor of the defendants.

CATHODIC FORMATION OF SODIUM ALLOYS.—In his American Electrochemical Society paper on the "Formation of Metallic Dust From Cathodes" (ELECTROCHEMICAL INDUSTRY, October, 1902, p. 60), Prof. F. HABER showed an experiment in which potassium hydroxide is electrolysed with a lead cathode; at a sufficiently high cathodic current density a black cloud was seen to go off from the cathode, the cloud consisting of fine particles of lead. The explanation of this phenomenon, given by Prof. Haber, is that primarily an alloy of lead and potassium is formed which cannot exist in contact with the solution and decomposes the water. If such an alloy is prepared chemically and brought in contact with water, the same phenomenon is observed. The cathodic formation of an alloy seemed to be indeed a very general phenomenon (see KAHLEN-

BERG, ELECTROCHEMICAL INDUSTRY, February, 1903, p. 201). The phenomenon is discussed by Dr. M. SACK, who gives the results of his investigation in a pamphlet on the formation of sodium alloys and their importance for the cathodic polarization (thesis, Technische Hochschule, Karlsruhe, 1903). The author studied the potentials of the sodium alloys of lead and tin and investigated whether the polarization phenomena at lead and tin in sodium hydroxide show simple relations to the potentials of these alloys. Such relations have, indeed, been found. The polarization phenomena are explained by the intermediate formation of the same sodium alloys which can be prepared chemically by fusing sodium and lead or tin together. The roughening of the surface is a preliminary step preceding the formation of dust from the cathode. Zinc and platinum are materials which, when used as cathodes, do not give up dust, but their surface becomes roughened. On the other hand, when lead and tin cathodes are used in sodium hydroxide, both a roughening of the surface and an evolution of dust are observed. The roughening of the cathode surface, which is combined with a strong evolution of hydrogen, takes place at lead at a cathodic potential of about 0.7 volt, at tin at 0.4 volt, against hydrogen in the same solution as zero. The evolution of metallic dust occurs at a lead cathode at a cathodic potential of about 1.5 volts, at tin at about 1.4 volts. The roughening of the surface of platinum and of lead is much greater when an acid is used as electrolyte than an alkali. This is explained as due to the fact that the discharged sodium cannot so easily enter into the pores of the cathodic metal, as the more mobile hydrogen. This shows that the hydrogen development from sodium hydroxide at these cathodes is essentially of secondary character.

Book Reviews.

BIBLIOGRAPHIE DER METALLLEGIERUNGEN. By Dr. M. Sack. Hamburg and Leipzig: Leopold Voss; 78 pages. Price, 70 cents.

This is a reprint in book form of the paper already referred to on page 429 of our August issue. As noticed there, this is a list of the literature on metallic alloys, which has evidently been prepared with the greatest care and appears to be complete. Eight hundred and eighty articles and papers are referred to, the arrangement being first alphabetically, according to the names of the authors. The name of the author, the title of the article, the journals in which it first appeared and in which it was afterwards abstracted, are given, together with a brief and concise statement of the special alloys which are dealt with in the article. A second list is arranged alphabetically according to the metals contained in the alloys. In view of the increasing industrial importance of alloys, the compilation of this list, which has certainly required an enormous amount of work, is highly creditable.

DIE HERSTELLUNG DER ACCUMULATOREN, EIN LEITFADEN
By E. Gruenwald, Halle: W. Knapp. Third edition.
Price \$1.00.

This small book is intended to be a pocket-book for the German storage battery engineer, and its appearance in the third edition shows that it has found many friends. It contains, indeed, in a concentrated form almost everything that is necessary for an introduction into this branch of engineering, and answers many questions that occur to the storage battery manufacturer. It is so complete as to give even the German laws for storage battery manufacturing plants, and the safety regulations of the German Association of Electrical Engineers. It may be acknowledged that the writer has taken peculiar pains to take advantage of all modern developments, both theoretical and practical, as far as possible.

RADIUM, AND OTHER RADIO-ACTIVE SUBSTANCES, POLONIUM, ACTINIUM AND THORIUM. With a Consideration of Phosphorescent and Fluorescent Substances, the Properties and Applications of Selenium, and the Treatment of Disease by the Ultraviolet Light. By William J. Hammer. New York: D. Van Nostrand Co. Price, \$1.00.

We are glad to note that the splendid and highly elaborate lecture delivered by Mr. William J. Hammer last spring, before a joint meeting of the American Institute of Electrical Engineers and the American Electrochemical Society, has now appeared in book form. It is the only book on the market which gives exact information on this subject, and is at the same time written in a clear and lucid style so that it should appeal not only to physicists and chemists, but to every educated man. The book should have a large sale.

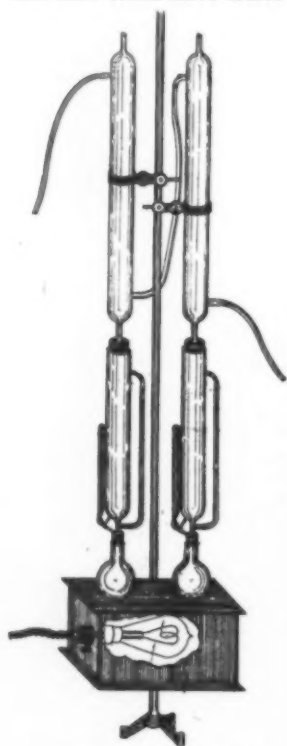
MODERN ELECTROLYTIC COPPER REFINING. By Titus Ulke, E. M., New York: John Wiley & Sons. Price \$3.00.

The task which confronts the reviewer of this book is a somewhat hard one. There is much to be praised and something to be deprecated. The chief fault of Mr. Ulke's writings is he draws inferences at times when it would be a safer and more conservative course to simply state what he knows

to be a fact. This reminds the reviewer of a story of a Swede who was about to return to the old country after a long sojourn in the land of the free and the home of the brave. Reaching the dock at 10:01 A. M., when the vessel was scheduled to sail at 10:00 A. M., he saw a narrow strip of void between the vessel and the dock. Crying for advice, he saw a friend hanging over the rail on the departing boat. This man answered his supplications by the exhortation, "yump, yump, Lars, you can do it in two yumps."

Mr. Titus Ulke has unfortunately tried to take two "yumps" where it would have been safer to have accepted the inevitable.

The point brought out in his preface that it was impossible to secure accurate descriptions of certain American refining plants is of course true. This is a perfectly natural course for the managers of these refineries to take, for the several refineries are at times engaged in



ETHER EXTRACTION.

strenuous competition to secure contracts for copper matte or bullion, and any information which one concern has and which others have not is a distinct commercial asset to the more fortunate concern.

The book, as books of technical matters go, is a very ably written and fairly complete resumé of the history of the development of electrolytic copper refining and is valuable for the brief account of the various metallurgical plants, which, considering the difficulties undergone in preparing the same, is quite accurate.

In Chapter I. all the principal problems involved in electrolytic copper refining are discussed in general. This chapter contains historical and statistical data, a comparison of the series and multiple system of cells, an outline of the chemistry and physics of refining, and a discussion of the treatment and purification of foul solutions.

In Chapter II. descriptions and views of electric copper-refining works in the United States, Great Britain, Germany, Austria-Hungary, France and Russia are given.

Chapter III. contains an estimate of the cost of an electrolytic copper and nickel refinery, with general plan and detail drawings. In an appendix a chronological list of patents, books and special articles on electrolytic copper-refining methods and apparatus is given.

Correspondence.

ETHER EXTRACTION BY ELECTRICAL HEAT.

TO THE EDITOR OF ELECTROCHEMICAL INDUSTRY:

Sir—An apparatus like the one illustrated here, has been in use nearly two years, and has been found to be a very satisfactory means of furnishing heat in making extractions with ether and other solvents of low boiling points. It also works to a nicety in evaporating from platinum dishes in making ash determinations, etc.

The bath shown here is 7 inches long, by 3 inches wide, constructed of copper and lined with corrugated asbestos 1-16 inch thick.

The apparatus is heated with one 32-candle-power lamp, on a 220-volt direct current, which gives a temperature of 115° centigrade in ten minutes after turning on the light.

A bath of the size mentioned here will operate two sets of extraction apparatus.

H. M. BURR.

Brooklyn, N. Y.

DRYERS.

In the adjoining diagrams we illustrate the latest types of dryers made by the Jeffrey Manufacturing Co., of Columbus, Ohio. Fig. 1 shows a dryer operated by live or exhaust steam, for drying pulverized or granular products, ores, chemicals, etc. The dryer consists of six steam-jacketed tubes, 12-inch inside diameter, each tube being provided with a 10-inch diameter extra heavy spiral conveyer. The conveyer being smaller than the tube, there is sufficient space for the moisture. It is provided with mixing paddles or lifting blades, which keep the material thoroughly agitated and all particles exposed to the surface of the steam jacket. The construction is clearly shown in the illustration.

The tubes really have two jackets, one for the steam and one for hot air. The steam occupies the space next to the conveyer. Outside of the steam jacket is located a hot air jacket, made of galvanized iron.

These six tubes are riveted to cast-iron nozzles or connecting spouts, which form the bearings for the screw conveyer. A steam dust or connection is cast into these spouts to allow the free circulation of steam from one tube to the other, forming a continuous flow of steam from the inlet of the upper tube to the drip pipe of the lower tube. The drip pipe allows the condensed steam to pass off. Each tube is provided with a pipe connection to the exhaust fan for drawing off the moisture. Instead of drawing cold air through the tube, hot air is introduced, the air being heated by passing through the air holes of the hot air jacket and through this jacket into the tubes, coming in direct contact with the material which is being carried through the same by the spiral conveyers. The hot air, after having passed through the tubes, passes into the exhaust pipe with the moisture that it has collected, and is thrown off by the suction fan. The air with the moisture is drawn through the tubes in the opposite direction from that of the material. By this operation the moisture is never drawn over that portion of the material from which the moisture has already been extracted. The same principle applies to each tube.

The steam tubes of the dryer are sufficiently strong to sustain a pressure of fifty pounds. At ten revolutions of the spiral

conveyers the capacity is approximately 250 cubic feet of material per hour. Of course, the capacity depends largely upon the nature of the material and the amount of moisture it contains. The speed of the fan should be about 800 revolutions per minute.

There are gate-valves in the suction pipes which draw away the moisture. These valves can be so adjusted that, as the material dries and becomes lighter, the amount of suction area can be cut off to suit.

The driving arrangement consists of cone pulleys on the

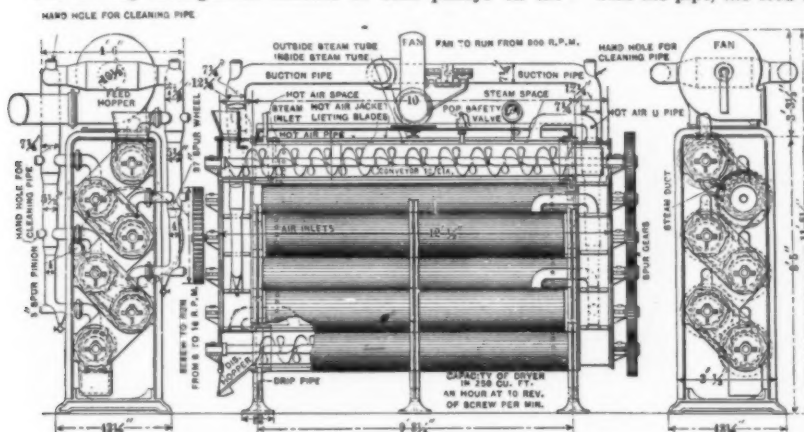


FIG. 1.—STEAM DRYER.

countershaft, also a small pinion, all attached to the drive frame, so that the speed of the spiral conveyers can be changed to 6, 8 or 10 revolutions, as the nature of the material may require. The spiral conveyers in the tubes are connected by means of spur gears.

The capacity stated above is based on ten revolutions, as mentioned before. Material containing a large percentage of moisture has to run through a longer period of time, and, consequently, the speed of the conveyers will have to be reduced. Where the material contains but little moisture, the speed of the conveyer can be increased.

Fig. 2 shows a rotary dryer, consisting principally of a steel drum or cylinder, 4 feet in diameter, 18 feet long, constructed of 5-16-inch steel plates, being supported by short shafts extending into each end of the shell and running in bearings located outside of the brick work. The cylinder is encased in brick work the entire length, provided at each end with cast-iron plates, having circular openings that fit neatly around its ends to prevent the escape of the hot air from the furnace.

At the receiving end of the dryer and below the driving gears, the furnace is located, having 20 square feet of grate surface, two fire doors and two ash doors. Above the grate surface and extending back to about two-thirds the length of the cylinder, is a brick arch which conducts the heat to the lower end of the cylinder. In this arch two cast-iron valves or dampers are placed under the cylinder to distribute a more uniform heat over the entire length; these valves or dampers can be opened and closed to regulate the heat according to the condition of the fire. Peep-holes are arranged on the side of

the furnace wall to allow the operator to see just how much to open or close the above valves. The heat and smoke from the furnace envelop the entire area of the cylinder and pass up into the stack, which is placed on the top brick arch near the receiving end.

An exhaust fan is placed at the receiving end of the dryer and connected to the inside of the cylinder, and also the stack. A circular steel casing is placed at the receiving end of the cylinder, fitting closely to the same and connecting to the fan with the pipe, the feed hopper or chute which carries the material to the cylinder passing through this circular casing.

The cylinder is provided with four internal angle-iron lifting blades, so that at every revolution the material is lifted four times, thus keeping it well scattered, allowing the free escape of all moisture, which latter is drawn off by the suction fan into the stack. This fan serves as a force draft for the furnace.

In the smoke stack, and also in the suction pipe connecting with the fan, valves are placed for the purpose of controlling the vapor suction and the furnace draft, these valves being under the convenient control of the operator.

A cone-shape receiving hopper is placed under the elbow of the exhaust pipe leading from fan to stack for the purpose of catching all fine or light material that may be lifted into the same by the fan, and by means of this hopper the material so collected can be drawn off when necessary. Should the collection of this material be considerable, it is evident that the

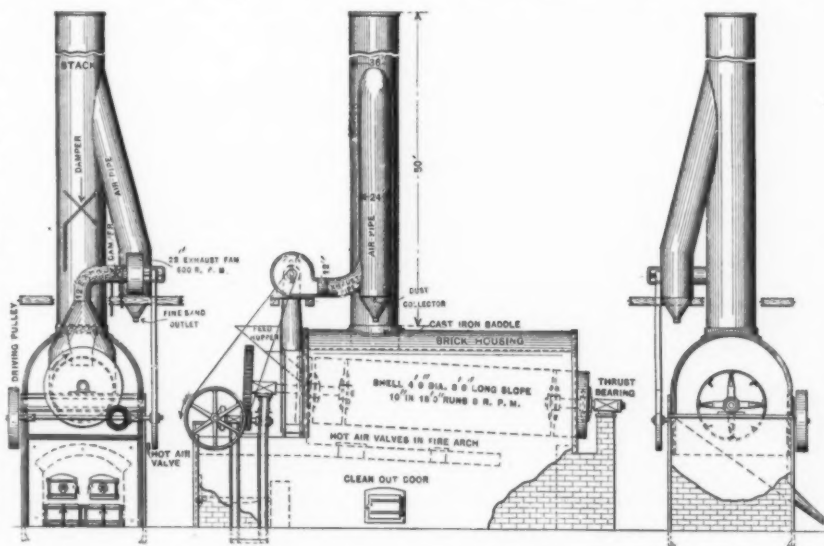


FIG. 2.—ROTARY DRYER.

fan is running too fast and should be slowed down until the desired results are obtained. The capacity of this dryer will depend upon the nature of the material and the amount of moisture it contains. If the material contains from 6 to 8 per cent of moisture, the capacity is estimated at from 8 to 10 tons per hour. With more or less moisture the capacity will vary proportionately.

The dryer is so arranged that no smoke or gas from the furnace can come in contact with the material, thus preventing

discoloration. On this account, any kind of fuel can be used, bituminous, slack, run of mine or lump, also coke, gas, oil or wood, whichever may be the cheapest in the locality where the dryer is to be operated.

MEASUREMENT OF HIGH TEMPERATURES.

Although the demand for a practical apparatus with which high temperatures can be measured is very large, science could meet this demand up to a short time ago only by instruments based on empirical rules. It is evident that the accuracy of measuring high temperatures was therefore somewhat limited. The well-known Le Chatelier thermo-element does not reach the limit of high temperatures. The color of glowing bodies was, therefore, mostly made use of for the approximate determination of their temperature.

As early as February, 1900, a description of a new method for measuring high temperatures was published by Dr. H. WANNER which was based on a new basis; namely, on a law which had first been theoretically deduced, and the correctness of which had been afterwards proven by extended experiments. He showed that by this new method the same value for the temperature of the electric arc light could be obtained as had been determined previously by other scientists by much more complicated methods. The new method showed a possibility of measuring temperatures up to 4000° C. and above. The following information is taken from a lecture of Dr. Wanner.

The law, as established experimentally, permits at least for a certain group of glowing bodies (the so-called theoretically "black bodies") the measurement up to the highest temperatures. When a compact body is heated, the rays emanating from the same may be observed by the human eye, and the body's color will change with rising temperature from dark red to light red, to yellow and to bright white. This means that at first mainly red rays are observed, to which, at the higher temperatures the other spectrum colors, orange, yellow, etc., are added, until the rays appear white. In analyzing the rays by a prism it is found that with the rise of temperature some single color, for instance, red, undergoes a rise in intensity which can be measured progressively with a specially constructed photometer. If we know the law for the mutual relation between the determining factors (the temperature, the light intensity of the single color, and its wave length) we are enabled to measure high temperatures by the photometric measurement of the light intensity of a certain color.

The apparatus to be applied is, therefore, a photometer, containing at the same time a prism to separate a single color. A spectrum is produced in the ordinary manner with the aid of a slit, lenses and a prism, from which, by means of a diaphragm, the light of a certain wave length is separated, and the measurement of the light intensity is made by polarization. To that part of the apparatus which faces the radiation to be examined, a small incandescent lamp is attached, the light of which is used for comparing the intensity of the light to be measured.

On looking through the apparatus one observes the circular field of vision, divided into two halves (like in a one-half shade sugar-testing polariscope), one of which is illuminated by the small incandescent lamp and the other by the light of the glowing body being examined. Both halves of the field show red color. On turning the eye piece containing the Nicol prism, both halves of the field vision can be easily brought to equal intensity, and on a circular scale the number of degrees are read. The actual temperature is found from a table which accompanies each instrument. The temperatures given on the table have been calculated by means of the law mentioned before.

The method may be considered from the following point of view. The electric comparison lamp is emitting rays of a known temperature with which the unknown temperature is being compared. The entire procedure is so simple that it can be readily learned by any foreman or intelligent workman

within a short time. The whole apparatus is 30 cm. long (12 inches), built like a telescope and can be easily handled without a support. It does not matter how great the distance is from which the measurements are taken, if only the field of vision is properly illuminated by the light emanating from the body to be examined.

The exactness of this new method depends solely on the accuracy of the observer and on the degree to which the body under test approximates what is called in the theory of radiation a "black body." Errors due to lack of experience of the observer are practically eliminated, for various parties, which have been asked to take measurements, and which used this apparatus for the first time, have obtained the same correct results. The nearest approximation to the theoretical "black body" are the insides of closed furnaces, as muffle furnaces, etc., the glow of which is observed through a small opening, which, however, must not be covered by glass or mica during the measurement. The measured temperature is equal to the real one within a few degrees.

By actual experiments Dr. Wanner obtained for blast furnace slag a temperature of 1321° C., for outpouring iron 1384° C., for slag pouring from the converter 1700° C. The temperature of the converter gases seemed to remain below 1500° C., however, the radiation of the flame causes a rise of temperature as decarburization, etc., progresses. The falling of the temperature, during the addition of scrap can be measured progressively, while the absolute temperatures cannot be obtained on account of the constant changeable transparency of the flame. The temperature of flowing steel can only be measured by looking directly upon the same.

The chief advantages of this new apparatus, whose sole agents for the U. S. A. are Messrs. EIMER & AMEND, of New York City, are reliability (because its indications are based on a law of nature, resting on the principles of thermodynamics, and not on an empirical rule), accuracy, handiness (it may be used with or without support), portability, and quick adjustment (requiring in practice but a few seconds). The instrument may be adjusted at the start to any desired temperature, thus showing exactly when this temperature is reached. Another special advantage of the apparatus is that it can be directed upon any visible part of the furnace in order to compare the temperature at different places in the furnace. It should be of the greatest value for iron and steel furnace men, for operators of electric furnaces, and, in fact, for everybody who wishes to measure exactly a high temperature.

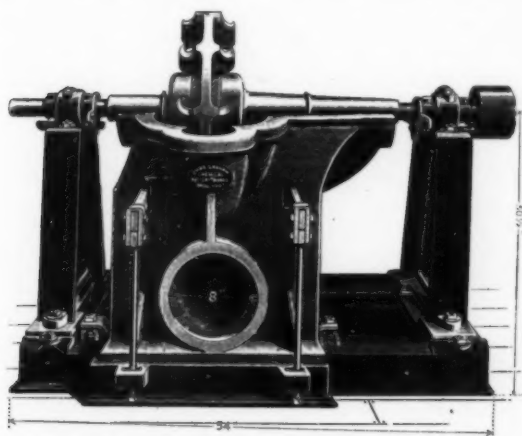
STONEWARE EXHAUST FAN

The accompanying illustrations show a stoneware exhaust fan, made by the Chas. Graham Chemical Pottery Works, of Brooklyn, N. Y. The primary purpose of these stoneware exhausters is to remove objectionable acid gases and to direct such gases through regenerative apparatus.

Wherever large chemical operations are carried on with acids, fumes are generated to an extent which seriously affects the health of the men. For instance, in the manufacturing of smokeless powder, nitric acid fumes are generated to such an extent as to make it almost impossible for men to work. By installing stoneware exhaust fans, the nitric acid vapors are rapidly removed and the conditions under which the men work are very greatly improved. At the same time a saving can be accomplished by the use of these fans, since the acid gases, instead of being allowed to escape, may be driven through the fan into stoneware towers, where they are regenerated for further use. These fans are generally useful for removing poisonous gases developed in electrochemical works, denitrating plants and in chloride of lime factories.

The exhaust fans of the Chas. Graham Chemical Pottery Works are made of vitrified stoneware of such a character

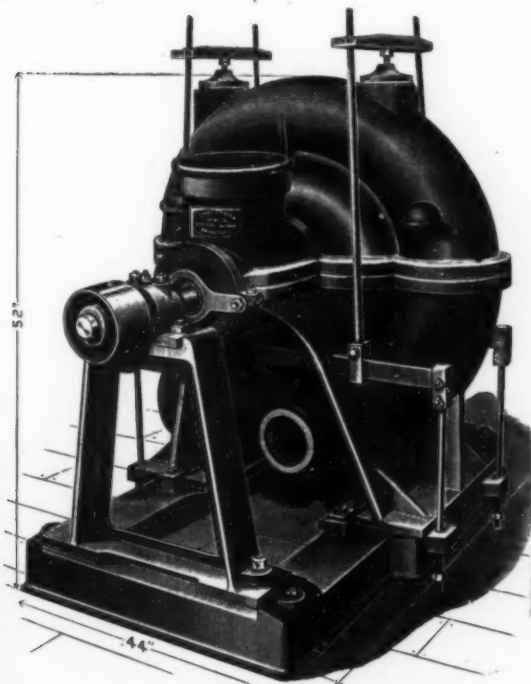
that it cannot be affected by the action of acid vapors. The construction of the fan is such that acid fumes cannot possibly come in contact with anything but the earthenware itself. The iron shaft which actuates the fan inside of the stoneware shell is covered in a thorough manner with earth-



Cross View

STONEWARE EXHAUST FAN.

enware sleeves, so that the acid gases have no chance to come in contact with the iron shaft. In this way the shaft is not only protected from the corrosive action of acid, but the purity of such acid as may be condensed in the fan is insured.



Front View.

STONEWARE EXHAUST FAN.

These fans are operated at a speed of 1200 revolutions per minute. Before shipping, the fan is set up in the factory and is tested thoroughly in actual operation. This precaution is very important, as at the high speed of operation a slight defect in the fan would be a serious matter. These exhaust

fans are made to be operated with either steam power or electric power.

The weight of the fan disc and sleeves is 90 lbs., that of the inlet piece 40 lbs., that of the top shell 190 lbs., and that of the bottom shell 355 lbs., so that all earthenware parts together weigh 675 lbs. Since the iron parts, including the base-plate, weigh 900 lbs., the total weight of the fan is 1575 lbs. The fan is shipped in assembled condition ready for operation. It is packed carefully in heavy timber frame, to make sure of its safe arrival at any destination. The total shipping weight is 1800 lbs.

The exhaust of this fan is at the rate of 2600 cubic ft. per minute. The diameter of section and exit opening is 8 ins., the diameter of the fan is 24 ins., the height of the whole apparatus is 52 ins., and the diameter of the operating pulley is 6½ ins.

Fig. 1 is a cross view and Fig. 2 a front view of the fan.

PERSONAL.

MR. BENJAMIN MAGNUS, superintendent of the Electrolytic Refinery and Silver Mill of the Anaconda Copper Mining Co., will shortly leave Montana, and expects to locate in the East.

MESSRS. LITTLE & WALKER, chemical experts and engineers, of Boston, Mass., announce the removal of their offices to 93 Broad Street, where they have greatly extended their facilities for handling all matters relating to technical chemistry.

INDUSTRIAL NOTES

STORAGE BATTERIES.—We have received from the Columbus Storage Battery Co., of Columbus, Ohio, their third annual catalogue of storage batteries. On the first 14 pages, an elementary discussion of the use and care of storage batteries is given; then follow some notes on features of the construction of the type of cell made by this company. The catalogue is concluded by a price list.

CHEMICAL STONWARE.—We have received from Messrs. Richard C. Remmey & Son, Philadelphia, Pa., their catalogue of chemical stoneware for manufacturing chemists. It is profusely illustrated, some of the subjects dealt with being stoneware cooling worms, chemical refining pots, various vessels and apparatus in close-grained mass, coolers or precipitating pots, stoneware corks, stills, evaporating dishes, connecting pipes and receivers, perforated pans for methylic anilin, apparatus for purifying and bleaching crude nitric acid, condensing towers, pipes, Glover towers, muriatic acid towers, acid pumps, etc.

CALORIMETERS AND PYROMETERS.—We have received from Messrs. Eimer & Amend, of New York City, their latest catalogue of calorimeters and pyrometers and other apparatus for measuring temperatures and determining the heating value of combustible gases, liquids and solids. The catalogue contains an extended illustrated description of the Junkers gas calorimeter; the Parr standard calorimeter for determining the heat units in bituminous and anthracite coal, lignites, coke, petroleum, etc.; various other types of calorimeters and pyrometers, especially the new platinum rhodium pyrometer (being a thermo cell). Among the other pyrometers briefly noticed there is the interesting optical pyrometer of Wanner, a description of which will be found on another page of this issue. The catalogue also contains a description of apparatus for rapid gas analysis by Elliott; sulphur apparatus in the improved form of Elliott; Weber's opal glass for photometer; standard photometer with accessories and Lummer-Brodhun prisms (the type used by the German Reichsanstalt) and a great many other apparatus for laboratory work. Especially apparatus for gas analysis are described and illustrated in various forms. Other subjects dealt with in the catalogue are acetylene gas generators, oil-testing apparatus, gasoline gas generators, hot-

air motors, etc. The mechanical make-up and the illustrations of the catalogue are very neat.

PUMP MANUFACTURING PLANT.—An extensive pump manufacturing plant, which is stated to be the largest in this country, and probably in the world, is now under construction, at Harrison, N. J. It is to be occupied by the firm of Henry R. Worthington, who employ about 3,000 men in their present works at South Brooklyn, L. I., and Elizabethport, N. J. The new plant at Harrison will accommodate from 4,000 to 5,000 men, and will cost in the neighborhood of two million dollars. It consists of a main machine shop with side galleries over 1,006 feet long, an erecting shop 592 feet long, and of the same section as the machine shop, and a high erecting shop 210 feet in length, and four galleries in height in the side bays connecting the two shops. The main foundry is 600 feet in length, and there is also a special foundry for small work, 410 feet in length, with a building 200 by 60 feet in size for cleaning castings connecting the two. The pattern building is four stories high and 550 feet long, and is divided by fire walls into four sections. The north section will be used for offices and drafting rooms; the adjoining section for the pattern shop and the balance of the structure for pattern storage. The power house, which will be equipped with the most modern boilers, engines and generators, is a building 172 by 102 feet. Electric power distribution is to be employed throughout. All will be connected by a complete system of railroad tracks entering the ends of the buildings and placing the works in direct communication with the Delaware, Lackawanna & Western, the Erie and the Pennsylvania Railroad systems. The new plant will be devoted entirely to the manufacture of water works machinery, water meters, cooling towers, condensers, feed-water heaters, centrifugal pumps and steam pumps of all kinds.

DIGEST OF U. S. PATENTS

PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend,
Patent Lawyers,
National Union Building, Washington, D. C.
CHEMICALS.

284,862. September 11, 1883. Mark H. Lackersteen, Chicago, Ill.

Converts neutral fats or oils into fatty acids and glycerine. First method: Melts the fat or oil, adds 12 per cent or more of water and intimately mixes to produce an emulsion, which is electrolyzed. The nascent oxygen and hydrogen from the water liberate the glycerine, which settles to the bottom and is drawn off. The cell is of copper or iron lined with copper, and may constitute one of the electrodes, the other being centrally placed in the vessel. Or the emulsion may be forced through a tube which contains, or portions of which constitute, the electrodes. Second method: Supports the melted fat or oil on water and electrolyzes the water only. The hydrogen and oxygen rise through the fat and effect the chemical reactions. In this method, the charge is kept in agitation by stirrer-arms and by steam blown upwards from a coil in the water above the electrodes. The steam jets the water upwardly into the fat and maintains the emulsion at a temperature from 250° to 350° F. The conversion is accelerated by the pressure produced in the cell by the liberated gases, this pressure being controlled by breaking the electric circuit as required. The electrodes here consist of a network of copper wire. The fat may first be cleaned by carrying out the second method with a small amount of injected steam. When the depuration is complete, the volume of steam is increased to blow the water upwards into the fat and form the emulsion. The vessel is preferably filled seven-eighths full of water and fat; one-eighth of water at the bottom and six-eighths of fat thereon.

322,940. July 28, 1885. Theodor Kempf, Berlin, Germany.

Produces iodoform, bromoform and chloroform by electrolyzing a heated, aqueous solution of the corresponding alkali or alkaline earth haloid, and alcohol, aldehyde or acetone. E. G. Electrolyzes a solution of 50 kg. of potassium iodide and 30 kg. of 96 per cent alcohol in 300 kg. of water, continuously injecting carbon dioxide and employing a current of 60 amperes. The iodoform separates as a crystalline powder. To obtain large crystals, the potassium iodide is dissolved in 20 per cent of alcohol. Bromoform or chloroform are produced from similar solutions without the injection of carbon dioxide, being distilled from the cell as produced.

326,657. September 22, 1885. Theodor Kempf, Berlin, Germany.

Produces permanganates by electrolyzing the corresponding manganate. Preferably employs a diaphragm cell, the base, for example, potassium hydroxide, being liberated in the cathode compartment.

339,727. April 13, 1886. Elias C. Atkins, Indianapolis, Indiana.

Passes electricity through the contents of a soap kettle to accelerate the production of soap. The kettle is steam-jacketed and contains a vertical, annular, central partition, spaced away from the bottom, in which is mounted a screw-shaped stirrer. This partition may constitute one electrode, the other consisting of three carbon plates set in a wooden frame. To treat a charge of 100 gallons, the potential difference is maintained at 50 volts for thirty minutes.

353,566. November 30, 1886. Mark H. Lackersteen, Chicago, Ill.

Modifies the process of his patent 284,862 to produce soap and glycerine. Electrolyzes an emulsion of the neutral fat or oil with an alkali, treated with dilute acid, or an emulsion with a solution of an alkali salt. E. G. Electrolyzes an emulsion of a melted fat and a saturated aqueous sodium chloride solution, in a diaphragm cell, the glycerine being set free at the anode and the alkaline base at the cathode where it combines with the fatty acids. The chlorine escapes from the anode compartment.

393,578. November 27, 1888. Leonard Paget, New York, N. Y.

Produces merchantable products by the action of a voltaic cell. E. G. Generates chlorine by the action of sulphuric acid on bleaching-powder and conducts it into a voltaic cell having an anode of zinc or iron, a cathode of lead coated with lead peroxide or a lead salt, and an electrolyte of water containing calcium carbonate in suspension. The chlorine maintains peroxidation of the lead, giving an e. m. f., with zinc, of 2.3 volts. The calcium carbonate in suspension is provided by dissolving calcium hydroxide or a calcium salt in the water and injecting carbon dioxide. The zinc or iron chloride produced by the action of the cell is recovered. The zinc may be placed in a solution of caustic soda contained in a porous cell immersed in the water. The e. m. f. is here 2.7 volts and the useful by-product is sodium zincate. May replace the chlorine by hydrobromic acid gas, produced by the action of hydrogen sulphide on bromine water. The voltaic cell then has a carbon or platinum cathode and an electrolyte of dilute sulphuric acid. The zinc or iron bromide is recovered. The voltaic cell is preferably closed, the pressure developed by the gases when the cell is on open circuit retarding the evolution of gas, while the decreased pressure due to the absorption of gases when the cell is on closed circuit may be employed to effect an automatic inflow of active material.

(To be concluded.)

